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THE EXTERNAL MORPHOLOGY OF THE ADULT TOBACCO HORNWORM

(Lepidoptera, Sphingidae)[1]

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A certain amount of attention has been devoted to the subject of the external morphology of the Sphingidae, but so far as is known, the complete treatment of any particular species has never appeared in the literature. In this paper a detailed description of the morphology of an adult of a typical species is presented, which may serve as an example of the structure of the entire family. The tobacco hornworm, *Protoparce sexta* (Johan.), was chosen for this purpose because of its large size and availability. This species is a common pest of tobacco and tomatoes throughout the greater part of the United States, and its range extends to the West Indies and Central and South America.

The specimens, which included both sexes, were collected in Gadsden County, northwestern Florida, and the descriptions and drawings are based upon the examination of a rather large number of individuals. The usual methods, consisting of removal of the scales and boiling or soaking the various parts in potassium hydroxide were followed in preparing the specimens for morphological study.

THE HEAD AND ITS APPENDAGES

Head capsule (figs. 1, 4, and 6).—The head capsule is a comparatively simple structure with few sclerites. The most prominent of the anterior region is the fronto-clypeus (*fc*) which is a broad, slightly convex sclerite demarked laterally by the ocular sutures (*os*) extending from the antennal sockets ventrally to the subgenal sutures. Slightly arched frontal sutures (*fr*), between the antennal sockets, separate the fronto-clypeus from the vertex. The ventral portion of the fronto-clypeus is

[1]Contribution from the Entomological Laboratory, Massachusetts State College.

[2]A portion of a thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science. Acknowledgments are due Dr. G. C. Crampton, under whose direction the problem was undertaken, for his valuable suggestions and kindly interest in the work.

abruptly convex and forms a blunt, snout-like protuberance over the base of the mouthparts.

The subgenal sutures (*sgs*) separate the fronto-clypeus from the subgenal region, which apparently merges on either side of the head with the triangular-shaped lobes representing the rudimentary mandibles. These sutures are arched above the frontal pits (*fp*), which are clearly discernible as vertically elongated depressions marking the invaginations that form the anterior tentorial arms. Since these pits normally occur only on the epistomal or subgenal sutures, they usually provide a means of determining the point of division between the frons and the clypeus. However, the principal dilator muscles of the cibarium (*dlcb*, fig. 6) arise upon the area above this point, and Snodgrass (1935, p. 119) states that these muscles arise on the clypeus. Therefore, it appears that the clypeus forms a larger portion of the frontal region of the head than is indicated by the position of the frontal pits.

The compound eyes (*e*) are subglobular and prominent. Their greatest development is ventro-posteriorly and they project beyond the ventral and posterior regions of the head capsule. The inner margins are curved slightly and are approximated ventrally to some extent. Narrow ocular sclerites (*oc*) separate the eyes from the fronto-clypeus. Dorsally, these sclerites apparently terminate at the antennal sockets and ventrally they appear to merge with the subgenal regions of the head. The development of the eyes has completely obliterated the genae.

Antennal sutures (*as*), touching the inner margins of the eyes laterally, demark the narrow antennal sclerites (*asc*) which border the antennal sockets. The antennal sclerites are expanded laterally, and each of these broader areas is produced into a blunt antennifer (*anf*) which extends into the antennal socket and forms the articulatory point for the basal segment of the antenna.

The vertex (*vx*) is a large convex area at the top of the head capsule. The dorsal edge of the frontal sutures is projected upward into this area suggesting a vestigial coronal suture, which in more generalized insects divides the vertex into two parietal sclerites. Traces of the coronal suture are indicated further by a pale, lightly-sclerotized

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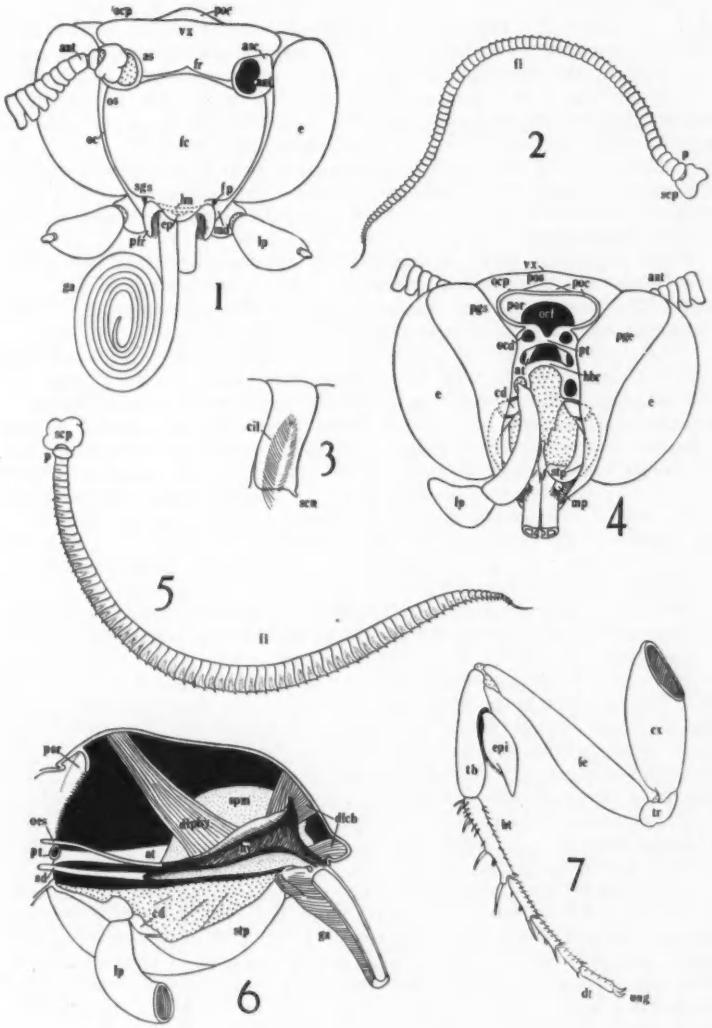
EXPLANATION OF PLATE I

FIGURE 1. Frontal view of head capsule (left antenna and palpus removed). 2. Antenna of female. 3. Lateral view of a segment of the male antenna. 4. Caudal view of the head capsule (right palpus removed). 5. Antenna of male. 6. Internal view of the left half of the head capsule. 7. Prothoracic leg.

Abbreviations: *anf*, antennifer; *ant*, antenna; *as*, antennal suture; *asc*, antennal sclerite; *at*, anterior arm of tentorium; *bt*, basitarsus; *cd*, cardo; *cil*, cilia; *cx*, coxa; *dlcb*, dilator muscle of cibarium; *dlphy*, dilator muscle of pharynx; *dt*, distitarsus; *e*, compound eye; *ep*, epipharynx; *epi*, epiphysis; *fc*, fronto-clypeus; *fe*, femur; *fl*, flagellum; *fp*, frontal pit; *fr*, frontal suture; *ga*, galea; *hbr*, hypostomal bridge; *hy*, hypopharynx; *lm*, labrum; *lp*, labial palpus; *md*, mandible; *mp*, maxillary palpus; *oc*, ocular sclerite; *ocd*, occipital condyle; *ocf*, occipital foramen; *ocp*, occiput; *oes*, oesophagus; *os*, ocular suture; *p*, pedicel; *pfr*, pilifer; *pge*, postgena; *pgs*, postgenal suture; *poc*, postoccipital sclerite; *por*, postoccipital ridge; *pt*, posterior arms of tentorium; *scn*, sense cone; *scp*, scape; *sd*, salivary duct; *sgs*, subgenal suture; *spm*, sucking pump; *stp*, stipes; *tb*, tibia; *tr*, trochanter; *ung*, unguis; *vx*, vertex.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line extending medially to the top of the head. There is no evidence of the two lateral ocelli which are located on the vertex in certain Lepidoptera.

The postoccipital sclerite (*poc*) borders the occipital foramen dorsally and laterally. It widens dorsally into a semi-circular lobe which projects outward over the occipital foramen, while ventral enlargements form the occipital condyles (*ocd*) which serve as articulatory points for the lateral cervical sclerites. Internally, the postoccipital suture forms a prominent postoccipital ridge (*por*) to which the anterior ends of the muscles moving the head are attached.

The occipital foramen (*ocf*) occupies a large portion of the posterior region of the head. The posterior arms of the tentorium (*pt*) form a bridge across the lower part, while the ventral margin is formed by the hypostomal bridge (*hbr*).

The postgenae (*pge*) occupy the spaces between the postocciput and the eyes, and extend anteriorly to the ventral surface of the head where they merge with the subgenal region. They are separated from the postocciput by the postgenal sutures (*pgs*).

The anterior arms of the tentorium (*at*) arise on the subgenal sutures near the margin of the labrum, their external manifestations being the frontal pits. They extend backward through the interior of the head capsule and connect with the posterior arms slightly mesad of the occipital condyles. The gular pits, which usually constitute the external manifestations of the posterior arms, are not apparent. However, it may be seen from the interior of the head that the posterior arms arise close to the lateral margins of the occipital condyles.

Antennae (figs. 2, 3, and 5).—The antennae consist of from 72 to 78 segments in both sexes. The scape (*scp*) is subcylindrical in shape and is larger than the succeeding segments, while the pedicle (*p*) is but slightly enlarged and is somewhat bulbous. The majority of the remaining segments, constituting the flagellum (*fl*), are cylindrical, and in the female they are all of approximately equal size. The tip in both sexes is composed of several relatively small segments arranged in the form of a recurved hook, while each segment of the flagellum, except the first five and all but the distal segment of the tip, bears a tooth-like sense cone (*scn*) near the apex. In the male, the segments of the flagellum are broadly rounded at the dorsal margin and are rather distinctly dialated laterally so that they appear somewhat triangular in cross-section. On each of these segments there is a subapical and subbasal row of long cilia (*cil*, fig. 3). These become fused dorsolaterally to form a flattened semicircle as seen from the lateral aspect.

Mouthparts (figs. 1, 4, and 6).—The labrum (*lm*) consists of a narrow transverse sclerite partly concealed from the cephalic aspect by the bulbous margin of the fronto-clypeus. It is produced ventrad into a mesal and two lateral lobes. The two large and prominent lateral lobes are the pilifers (*pfr*), while the small mesal lobe represents the epipharynx (*ep*) in part. The pilifers resemble mandibles superficially but a closer examination shows that the mandibular lobes are distinct.

The large, convex, triangular mandibles (*md*) lie behind the pilifers. There is no point of articulation with the head capsule, and there are no definite sutures demarking the mandibles from the subgenae. However, vestiges of such sutures may be detected in some specimens.

The maxillae are the largest and most important of the mouthparts. The triangular-shaped cardo (*cd*) articulates with the anterior margin of the sclerotized portion of the labium, and the subcylindrical stipes (*stp*) is curved mesally and is almost completely concealed beneath the projecting portion of the subgena. The single-segmented maxillary palpus (*mp*) is somewhat palmate in shape and is greatly reduced in size. It is borne on the anterior portion of the stipes near the point of attachment to the galea.

The galeae (*ga*), or proboscis, constitute the greater part of the maxillae. The inner surfaces are concave and the margins are held together firmly by interlocking grooves to form a long sucking tube. The basal portion of the tube opens into the sucking-pump (*spm*) which is well developed and narrows posteriorly into the oesophagus (*oes*). The floor of the pump is formed by the hypopharynx (*hy*). When not in use the proboscis is held tightly coiled beneath the head, and Schmitt (1938) states that extension is effected by the compression of the stipes which forces blood into the galeae and causes them to straighten. Muscles within the galeae cause them to recoil when the tension on the stipes is relaxed.

The structure of the labium is rather indefinite and the sclerotized portions are limited to small areas around each labial palpus, and to a short, narrow, median strip proximad of the base of the proboscis. The remainder probably is represented by the membranous portion of the ventral surface of the head. The labium is supported posteriorly by the hypostomal bridge.

The labial palpus (*lp*) consists of three segments. The basal segment is well developed and is curved forward and upward in such a way that the remaining segments are applied closely to the anterior surface of the head. The second segment is large and stout, but the third is relatively small. On the distal end there is a ventral pit which is lined with short hairs and apparently represents a sensory organ.

THE THORAX AND ITS APPENDAGES

Cervix (figs. 13 and 18).—The cervix is an intersegmental region lying between the head and prothorax. It is almost entirely membranous, sclerotization being limited to a pair of V-shaped lateral cervical sclerites (*lc*). The apex of the V articulates with the anterior margin of the prothoracic episternum and is prolonged beyond the point of articulation as a short, free stem. The distal ends of the dorsal arms, or cephaligers, articulate with the occipital condyles, while the ventral arms are united by an extremely narrow bridge.

Prothorax (figs. 8, 13, and 18).—The prothorax is greatly reduced in size and is largely membranous.

The pronotum (*pn*) consists of three small plates partially fused together and arranged in the form of a Y. The proximal portion of the posterior plate articulates with the anterior margin of the mesothoracic prescutum, which forms a bowl-shaped depression at this point, and the anterior plates are curved around the dorsal portion of the anterior opening into the thorax. The posterior margins of these plates are broadly rounded, and their ventral margins are partially fused with the episternal sclerites. The patagia (*pg*), consisting of two

flattened lobes, are supported by the dorsal margins, and directly behind the patagia lie another pair of larger lobes which Schultz (1914) terms the parapatagia (*par*).

The episternum (eps_1) is a convex sclerite partially fused with the ventral margin of the pronotum. All traces of the epimeron have disappeared, but the pleural suture (*ps*) is very distinct and forms a prominent internal ridge for muscle attachment. This ridge is produced ventrally on each side into two pleural arms (*pa*) which fuse with the furcal arms (*fa*). The episternum is connected with the anterior portion of the sternum by a narrow precoxale (*pr*) which passes in front of the coxal cavity. There is no trace of the postcoxale which in many insects connects the epimeron with the sternum behind the coxal cavity.

The basisternum (bs_1) is reduced to a narrow region representing the edges of a deep, median fold. It broadens slightly into a posterior furcasternum distinguishable by the invagination giving rise to the furcae which are produced dorsally as the furcal arms.

The spinasternum (*ss*) extends almost vertically inward and then outward forming an internal strap-like process. On the exterior, it forks into two lateral arms which almost touch the anterior margin of the mesothoracic basisternum.

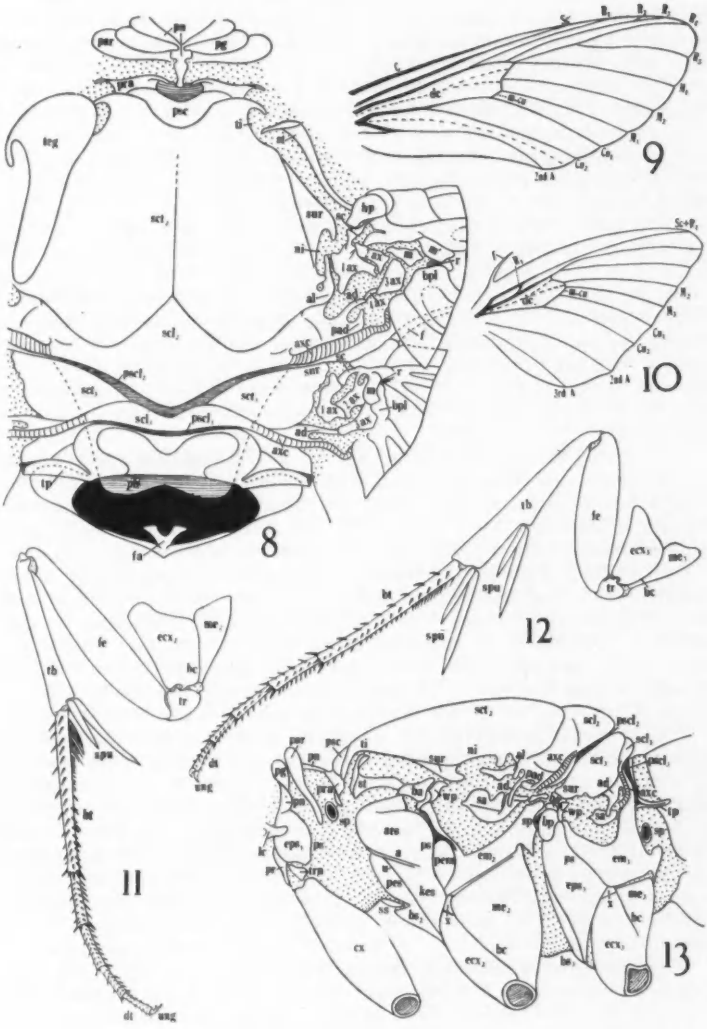
Mesothorax (figs. 8, 13, and 18).—The prescutum (*psc*) is a small, strongly convex sclerite lying partially in a deep semicircular cleft in the anterior margin of the scutum. It is directed ventrad and is almost invisible from the dorsal aspect. A broad, bowl-shaped depression occurs near the anterior margin, and the lateral margins are produced into two narrow prealars (*pra*) extending to the pleura.

The scutum (scl_2) is the largest of the thoracic tergites. The anterior margin is deeply cleft, and the lateral margin is deeply notched caudad of the prealar sclerite to form the tegular incision (*ti*). Behind this point, the lateral margin is flattened into a suralare (*sur*) which

EXPLANATION OF PLATE II

FIGURE 8. Dorsal view of thorax (right tegula removed). 9. Fore wing. 10. Hind wing. 11. Mesothoracic leg. 12. Metathoracic leg. 13. Lateral view of thorax (tegula removed).

Abbreviations: *A*, anal vein; *a*, anepisternal suture; *ad*, adanale; *aes*, anepisternum; *al*, adnotale; *1 ax*, first axillary; *2 ax*, second axillary; *3 ax*, third axillary; *4 ax*, fourth axillary; *axc*, axillary cord; *ba*, basalare; *bc*, basicostal suture; *bp*, basalar pad; *bpl*, basoplica; *bs*, basisternum; *bt*, basitarsus; *C*, costa; *Cu*, cubitus; *cx*, coxa; *dc*, discal cell; *dt*, distitarsus; *ecx*, eucoxa; ecx_2, mesothoracic eucoxa; ecx_3, metathoracic eucoxa; em_2, mesothoracic epimeron; em_3, metathoracic epimeron; eps_1, prothoracic episternum; eps_3, metathoracic episternum; *f*, frenulum; *fa*, furcal arms; *fe*, femur; *hp*, humeral plate; *kes*, katepisternum; *lc*, lateral cervical sclerite; *M*, media; *m*, proximal median plate; *m'*, distal median plate; *m-cu*, medio-cubital crossvein; *me*, meron; me_2, mesothoracic meron; me_3, metathoracic meron; *ni*, notal incision; *pad*, postadanale; *par*, parapatagium; *pem*, preepimeron; *pes*, preepisternum; *pg*, patagium; *ph*, postphragma; *pn*, pronotum; *pr*, precoxale; *pra*, prealar; *ps*, pleural suture; *psc*, prescutum; $pscl_2$, mesothoracic postscutellum; $pscl_3$, metathoracic postscutellum; *R*, radius; *r*, marsupium; *Rs*, radial sector; *sa*, subalare; *Sc*, subcosta; *sc*, head of subcostal vein; scl_2, mesothoracic scutellum; scl_3, metathoracic scutellum; scl_2, mesothoracic scutum; scl_3, metathoracic scutum; *sp*, spiracle; *spu*, spur; *ss*, spinasternum; *st*, subtegula; *sur*, suralare; *tb*, tibia; *teg*, tegula; *ti*, tegular incision; *tp*, tergo-pleural groove; *tr*, trochanter; *trn*, trochantin; *u*, preepisternal suture; *ung*, unguis; *wp*, pleural wing process; *x*, epicoxal piece.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serves as an anterior pivotal point for the wing. The median carina is quite distinct posteriorly, but becomes obliterated as it passes forward.

The subtegula (*st*) lies in the membrane laterad of the suralare. The anterior plate is directed into the tegular incision, while the longer posterior plate passes backward to the pleural wing process and serves as a prop for the anterior plate.

The tegula (*teg*) is a large, thin plate rather strongly convex anteriorly. It is supported by the subtegula to which it is attached. The anterior margin lies slightly cephalad of the tegular incision, and the posterior portion extends nearly to the base of the scutum. The antero-lateral margin is produced backward into a long, slender process which passes beneath the base of the forewing.

The postero-lateral margin of the scutum consists of a flat extension containing two lobes with a deep notch lying between them. The anterior lobe, or adanale (*ad*), is long and slender and serves as the posterior articulatory point for the wing, while the posterior lobe is shorter and stouter and represents the postadanale (*pad*). Between the suralare and the adanale, the lateral margin of the scutum is extended into a forward projecting adnotale (*al*) which functions also as an articulatory point for the wing. A deep notal incision (*ni*) lies in the edge of the scutum between the adnotale and the posterior margin of the suralare.

The scutellum (scl_2) is a small V-shaped sclerite. The membranous axillary cords (*axc*) are continuous with the posterior marginal fold, and extend along the posterior margin of the postadanales to the anal regions of the wings.

The postscutellum ($pscl_2$) is a very narrow sclerite partially concealed within a depression between the scutellum and the scutum of the metathorax. The intersegmental fold between the postscutellum and the metathoracic scutum forms a huge internal postphragma (*ph*) which is developed to such an extent that the dorsal organ and alimentary tract are forced into the ventral region of the body cavity in order to pass beneath. The postphragma affords one of the principal points of attachment for the dorso-lateral mesothoracic muscles.

The pleuron is divided by a vertical pleural suture (*ps*) into an episternum and an epimeron (em_2). A transverse anepisternal suture (*a*) divides the episternum into a dorsal anepisternum (*aes*) and a ventral katepisternum (*kes*) which continues as a narrow precoxale and fuses with the furcasternum. The lobe-like preepisternum (*pes*) fuses ventrally with the basisternum, and is separated from the katepisternum by the preepisternal suture (*u*). A fold in the dorsal margin of the anepisternum may represent the basal portion of the basalare, but the basalare proper (*ba*) is a small, partially detached, triangular plate lying dorsad of the fold.

The epimeron is almost V-shaped, and a distinct suture cuts off the anterior portion into a subcircular region which Shepard (1930) calls the preepimeron (*pem*). The anterior margin of the preepimeron overlies the pleural suture, and its upper portion lies in a cavity parallel with the suture and extending forward into the anepisternum. The narrow antero-dorsal portion of the epimeron overlies this cavity and is produced dorsally into a pleural wing process (*wp*). The epimeron

tapers to a sharp point immediately caudad of the meron and does not form a postcoxale.

The subalare (*sa*) lies in the membrane above the epimeron. Important wing muscles are inserted upon this plate and it is invaginated mesally for this purpose. A small narrow plate, which apparently represents a second subalare, is located directly behind the subalare.

The mesothoracic spiracle (*sp*) has migrated forward and lies in the pleural membrane of the prothorax caudad of the pleural extension of the parapatagia.

The basisternum (bs_2) is a broad, wedge-shaped sclerite which is inrolled to form a mid-ventral suture (*mv*) resembling an internal keel-shaped ridge. The furcasternum (fs_2) is a small, triangular, deeply infolded plate, and the median invagination forms a pair of broad furcal arms which are directed slightly caudad. The ends of these arms fuse with the posterior portions of the epimera to form a brace across the caudal end of the mesothoracic cavity. There is no apparent connection between the furcal arms and the pleural ridge, which is a very unusual condition. However, the structure of the endoskeleton is so complicated by additional invaginations and infoldings that this point cannot be determined definitely.

Metathorax (figs. 8 and 13).—The scutum (sct_3) consists of two lateral, lobe-like sclerites. The anterior margins are produced slightly to form the suralares (*sur*), and the flattened posterior margins are produced into two long, narrow adanales (*ad*). The scutellum (scl_3) is a narrow transverse plate lying across the base of the scutum. The anterior margin is sinuate, and the lateral margins are produced into membranous axillary cords (*axc*) which extend to the anal region of the hind wings. The postscutellum ($pscl_3$) lies immediately caudad of the scutellum, and is represented mainly by a deep invagination forming a large, internal phragma upon which a great number of muscles are attached. The membranous portion of the first abdominal tergite is attached to the posterior margin of the postscutellum.

The metapleuron is divided by a vertical pleural suture (*ps*) into an anterior episternum (eps_3) and a posterior epimeron (em_3). The episternum fuses ventrally with the basisternum, and on its dorsal margin there is a weakly-sclerotized, subcircular pad which Shepard (1930) calls the anterior basalare, or basalare pad (*bp*). The metathoracic spiracle (*sp*) lies directly beneath the basalare pad, and the small quadrate basalare (*ba*) is located immediately above it, while the small vertical pleural wing process (*wp*) lies caudad of the basalare. The wing process, basalare, and basalare pad represent structures for wing support and for the attachment of wing muscles.

The subalare (*sa*) lies in the membrane above a deep emargination in the dorsal margin of the epimeron. A latero-ventral extension of the postscutellum fuses with the posterior region of the epimeron to form a postalar bridge, and the upper portion of this bridge becomes deeply infolded and merges with the invagination of the postscutellum.

The basisternum (bs_3) is reduced to a very narrow precoxale in front of the coxal cavity. The furcasternum is reduced correspondingly and the apophyses arising from it branch dorsally into an anterior and a posterior pair of furcal arms (*fa*). The anterior arms are short and

stout, while the posterior arms are much longer and fuse with the ventral margin of the epimeron to form a narrow postcoxale which is attached to the membrane of the anterior margin of the basal abdominal sternite. There is no apparent connection between the furcal arms and the pleural ridge which corresponds with the condition existing in the mesothorax.

Legs (figs. 7, 11, 12, and 15).—The coxa (*cx*) of the prothoracic leg is an elongated, cylindrical segment which is broadest near the base and tapers toward the distal end. It articulates proximally with the trochantin (*trn*), but the coxae of the meso- and metathoracic legs are immovably united with the pleura. The latter are divided by a basicostal suture (*bc*) into an anterior eucoxa (*ecx*) and a posterior meron (*me*) which are produced distally into trochantifers articulating freely with the condyles of the trochanter. A triangular plate at the base of the coxa of the meso- and metathoracic legs, lying between the katepisternum and the meron, is separated from the eucoxa by the basicostal suture. Snodgrass (1909) calls this plate the trochantin, but Shepherd (1930) calls it the epicoxal piece (*x*, fig. 13).

The trochanters (*tr*) of all the legs are subglobose and of about equal size. The only point of articulation is between the condyle and the trochantifer, as the distal end is immovably attached to the femur in each case.

The femora (*fe*) of the pro- and mesothoracic legs are nearly twice the length of those of the metathoracic legs. The posterior margin of the femur of the prothoracic leg is broadly rounded proximally but tapers sharply toward the distal end, thus providing a space for the accommodation of the epiphysis when the femur and tibia are folded together. The femora are clothed with long hairs, but do not bear spines, spurs, or setae.

The tibia (*tb*) of the prothoracic leg is rather short and stout and the base of a prominent claw-like epiphysis (*epi*) rests in a long cavity in the posterior margin. The tibia of the mesothoracic leg is about one and one-half times the length of the prothoracic tibia. It is rather slender, but widens toward the distal end which is armed with a pair of stout spurs (*spu*). The outer spur is about twice the length of the

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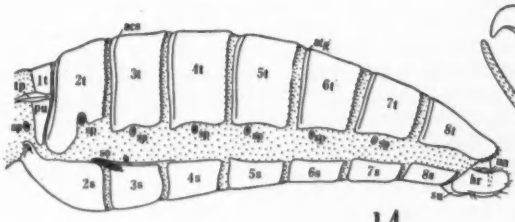
EXPLANATION OF PLATE III

FIGURE 14. Lateral view of abdomen of male. 15. Pretarsus. 16. Lateral view of female genitalia. 17. Lateral view of male genitalia (right harpe removed). 18. Ventral view of pro- and mesothoraces. 19. Ventral view of female genitalia.

Abbreviations: *a*, anepisternal suture; *acs*, antecostal suture; *aed*, aedeagus; *aes*, anepisternum; *an*, anus; *ar*, arolium; *atg*, acrotergite; *au*, anellus; *ba*, basalare; *bs*, basisternum; *dt*, distitarsus; ecx_2, mesothoracic eucoxa; em_2, mesothoracic epimeron; *emp*, empodium; eps_1, prothoracic episternum; *fa*, furcal arms; *fs*, furcasternum; *gn*, gnathos; *gp*, genital plate; *hr*, harpe; *jx*, juxta; *kes*, katepisternum; *lc*, lateral cervical sclerite; me_2, mesothoracic meron; *op*, oviporus; *or*, orbicula; *ost*, ostium; *pa*, pleural arm; *par*, parapatagium; *pem*, preepimeron; *pes*, preepisternum; *pg*, patagium; *pl*, planta; *pn*, pronotum; *pr*, precoxale; *pu*, pleural sclerite; *pv*, pulvillus; *rec*, rectum; *s*, sternite; *sac*, sacculus; *so*, scent organ; *sp*, spiracle; *ss*, spinasternum; *su*, saccus; *t*, tergite; *teg*, tegula; *ten*, tendon; *tg*, tergum; *tp*, tergo-pleural groove; *trn*, trochantin; *ts*, transtilla; *u*, preepisternal suture; *un*, uncus; *ung*, unguis; *ut*, unguitractor; *utt*, unguitractor tendon; *v*, vinculum; *x*, epicoxal piece.



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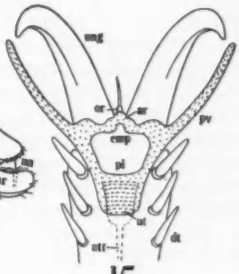

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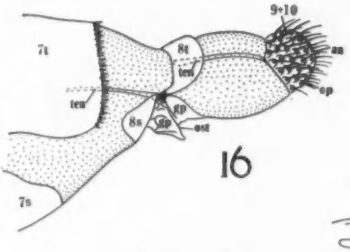

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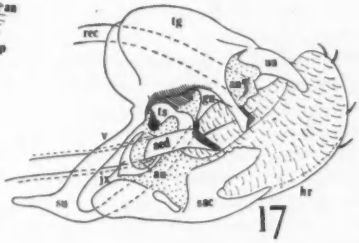

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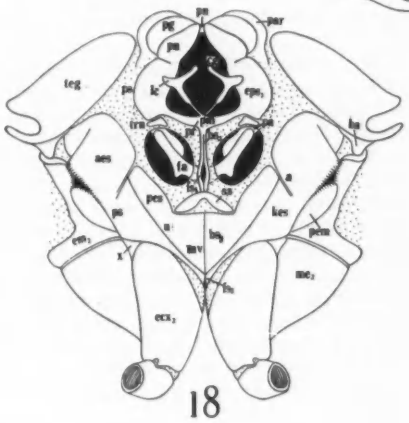

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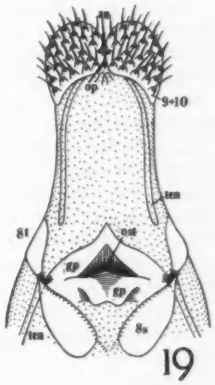

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inner, and is almost one-half as long as the tibia. The metathoracic tibia is about twice as long as the prothoracic tibia and is armed with two pairs of spurs. The longer spur of each pair is on the outer side.

The tarsus of each leg is composed of five segments. The basitarsus (*bt*) is the longest and it is longer in the middle and hind legs than in the fore legs. In the hind leg, it is over three times as long as any of the other segments. The segments become progressively shorter and the shortest is the distitarsus (*dt*). There are three irregular rows of stout spines on the posterior margin of the fore-tarsus, and a number of irregularly placed spines and four or five medium-sized spurs on the anterior margin of the basitarsus of the fore leg. Each tarsus of the middle and hind legs bears four rows of bristles, and in the proximal portion of the basitarsus, especially in the middle leg, the spines of the posterior row are long and bristle-like.

A pretarsus (fig. 15) is present at the tip of the distitarsus of each leg. The most prominent part is the two large, curved ungues (*ung*) which articulate with the dorsal margin of the distitarsus by means of small, hook-shaped unguifers. Two membranous pulvilli (*pv*) arise from the membrane at the base of the claws, and proximad of the bases of the claws there is a broad sclerite with a median elongation at the distal margin. The basal portion of this sclerite apparently represents the planta (*pl*), while the distal elongation is probably the empodium (*emp*). The arolium (*ar*) has been reduced to a small, membranous area above the empodium. On its dorsal surface there arises a tiny, cylindrical, sclerotized orbicula (*or*). The base of the planta is separated slightly from a narrow, ventral sclerotized unguitractor (*ut*) which is partially withdrawn into the distitarsus. The unguitractor tendon (*utt*) is attached to the proximal margin of the unguitractor and extends upward into the tibia.

Wings (figs. 8, 9, and 10).—The forewings are elongate-triangular in shape. The apical angles are acute, and the anal angles are distinct. The outer margins are crenulate and somewhat shorter than the inner margins, which are slightly sinuate. The hind wings are much shorter and wider and more triangular in shape than the forewings, and the apical and anal angles are broadly rounded.

The venation, which is interpreted according to the Comstock-Needham system, is shown clearly in figs. 9 and 10. In both the fore and hind wings, the basal portion of media has atrophied (hypothetical position indicated by dotted lines), and the remainder has become reduced to a three-branched condition. The first anal has atrophied in the forewing, but a vestige remains as a distinct anal furrow, which is indicated also by a dotted line. The second anal (*2nd A*) is retained, but all that remains of the third anal appears as a basal fork of the second. In the hind wing, the first anal has atrophied, but the second and third anals have been retained.

The wings are attached to the body by articular membranes which contain several axillary sclerites. The humeral plate (*hp*), at the anterior margin of the base of the forewing, articulates with the base of the costal vein. The first axillary (*1 ax*) lies caudad of the humeral plate, and the anterior arm articulates with the lateral margin of the suralare and the head of the subcosta (*sc*). The posterior portion

articulates with the adnotale, while the antero-lateral portion articulates with the second axillary (*2 ax*) which in turn articulates with the base of the radial vein and the pleural wing process. The flexor muscles of the wing are inserted on the triangular third axillary (*3 ax*), which lies caudad of the second. It articulates with the second axillary and the base of the anal vein. A very small fourth axillary (*4 ax*) articulates with the third axillary and the adanale. The proximal median plate (*m*) lies distad of the second and third axillaries, and a distal median plate (*m'*) lies slightly distad of the first. Caudad of the proximal median plate and the third axillary there is a basal knob, or basoplica (*bpl*) which fits into an anterior pocket, or marsupium (*r*) when the wings are flexed horizontally over the abdomen. Similar axillary sclerites occur in the articulatory membrane of the hind wing, with the exception of the humeral plate, distal median plate, and fourth axillary.

A frenulum (*f*) projects forward from the humeral angle of the hind wing. In the male, the frenulum is a stout, spine-like organ which is directed beneath the fore wing where the end is received in a flat, sclerotized catch, or frenulum hook, rising from the membrane between the costa and the subcosta on the ventral side of the wing. In the female, the frenulum consists of a group of about ten spine-like bristles. The tips of these bristles may be engaged in a cluster of hairs, known as the retinaculum, which occur ventrally at the base of the cubitus in the fore wing. The function of the frenulum is to coordinate the movement of the wings in flight.

THE ABDOMEN AND GENITALIA

Abdomen (fig. 14).—The abdomen is elongate-conical in shape, and is composed of ten segments. However, since the last two or three are reduced and modified to form the genitalia and are retracted within the last visible segment, there are only eight apparent segments in the male and seven in the female.

The sclerotized portions of the segments consist of a tergite (*t*) and a sternite (*s*). These are separated by a membranous pleural region bearing the seven abdominal spiracles (*sp*). The segments are connected by conjunctival membranes, and each tergite and sternite normally overlaps the following tergite and sternite. A narrow acrotergite (*atg*) is demarked by a faint antecostal suture (*acs*) in all the tergites of the unmodified segments except the first. This suture forms an internal antecosta upon which the principal dorso-longitudinal muscles are attached. There is a double row of stout spines on the posterior margins of the tergites mentioned above, and there is a single row of weaker spines on the posterior margins of the corresponding sternites.

The first abdominal tergite is greatly reduced and supports a long narrow plate on its lateral margin. This plate extends forward and fuses with the edge of a fold in the posterior margin of the metathoracic postscutellum. A deep groove occurs in this plate which, according to Forbes (1923), represents the tergo-pleural groove (*tp*). A small pleural sclerite (*pu*) lies below the plate. The anterior portion of the second tergite is extended into the pleural region and probably rep-

resents the second abdominal pleurite, although it is not demarked from the tergite by a suture. None of the remaining segments have sclerotized areas in the pleural region.

The first abdominal sternite fuses with the second to form a wide plate beneath both the first and second tergites. There is a deep invagination near the upper anterior margin of this plate which gives rise to a hook-shaped process upon which certain muscles are attached.

The orifice of a scent organ (*so*) lies in the pleural membrane above the dorsal margin of the second sternite in the male, and a groove extends backward from this opening to a point above the fourth sternite. The surface of the orifice is covered with a tuft of long hairs.

Male Genitalia (figs. 14 and 17).—The male genitalia are composed of the highly modified ninth and tenth abdominal segments. In discussing their structure, the terminology of Eyer (1924) will be followed almost exclusively.

The tergum (*tg*) apparently represents the ninth tergite. It is strongly arched dorsally and tapers slightly toward its posterior extremity. The tergum fuses ventrally with the ninth sternite, or vinculum (*v*), which is a narrow, sclerotized band enclosing the basal portion of the genitalia and extending anteriorly to form a medio-ventral invagination, or saccus (*su*).

The paired harpes (*hr*) articulate with the posterior margin of the vinculum. They are somewhat spatulate in shape, and with the exception of certain regions are very weakly sclerotized. The inner surface of each is concave and is covered with long hairs. The dorsal region is thickened and rather heavily sclerotized, and the ventral region, or sacculus (*sac*), is heavily sclerotized and is produced into a curved inner process. The distal portion of this process is free and consists of a ventral prong separated by a deep incision from a broader upper portion with a partly serrate dorsal margin. The shape of the sacculus is constant, and it is therefore of importance in classification.

The inner dorsal angles of the harpes are connected by a transtilla (*ts*) with deeply invaginated ends which form articulatory points for the harpes. Lying within the vinculum is a cone-shaped anellus (*au*) through which the aedeagus enters the abdomen. The anellus is invaginated to form a membranous tube surrounding the aedeagus, and the ventral portion is heavily sclerotized externally forming a yoke-shaped juxta (*jx*) which supports the aedeagus. The aedeagus (*aed*) is a long sclerotized tube which serves as a protective armature and guide for the penis.

The anal armature belongs to the tenth segment and is composed of two parts. The uncus (*un*) is a single, ventrally inclined hook projecting over the anus. Superficially, it appears to be attached to the tergum because of the retraction of the tenth segment. The gnathos (*gn*) consists of paired arms arising from the tergum at the base of the uncus. The median ventral plate, which in some insects lies between the arms, is missing and the arms fuse to form a trough-like projection ventrad of the anus. The anus (*an*) marks the external opening of the rectum (*rec*) which is in the form of a membranous tube closely applied to the tergum internally.

Female Genitalia (figs. 16 and 19).—The eversible female genitalia are normally retracted within the seventh somite. They are still further concealed by a thick clothing of long hairs. The basal portion is made up of the eighth tergite and sternite. The eighth tergite is a simple semicylindrical plate which narrows abruptly at the point of union with the sternite. A deep invagination is formed at this point giving rise to an elongated tendon (*ten*) which extends forward into the body cavity. A similar tendon arises from an invagination in the anterior margin of the ninth segment and extends forward beneath the eighth tergite, and corresponding tendons arise on the opposite side of the genitalia. Muscles involved in the retraction of the genitalia are attached to these tendons.

The ostium (*ost*), which forms the external opening of the ductus bursae, or vagina, lies ventrad of the eighth tergite, and a part of the eighth sternite is modified to form sclerotized genital plates (*gp*) surrounding the ostium. Two partially invaginated lobes of the eighth sternite extend cephalad and are approximated mesally. A membranous tubular extension, which functions as an ovipositor, lies caudad of the eighth segment, and two sclerotized, hemispherical lobes form the terminus of this extension. These lobes are frequently referred to in the literature as the ninth segment, but Snodgrass (1933) states that they evidently represent the united ninth and tenth somites. They are covered with tubercles bearing long setae. The anus (*an*) and the opening of the oviporus (*op*) lie between these lobes. The oviporus, which is ventrad of the anus, represents the external opening of the egg duct. It forms also a posterior opening of the genitalia, a condition found only in certain Lepidoptera and in the Mecoptera. Two short, weakly sclerotized, finger-like processes lie directly below the oviporus. These processes undoubtedly function as auxillary guides in placing the egg.

SUMMARY

1. A detailed morphological description of the adult is presented as an example of the structure of the entire family.

2. The head capsule is a relatively simple structure and the mouthparts are greatly reduced. The maxillae are the largest and most highly developed of the mouthparts.

3. The cervix is almost entirely membranous.

4. The prothorax is greatly reduced in size, while the mesothorax is greatly enlarged and its structure is very complex. The metathorax is somewhat smaller than the mesothorax and is less complicated in structure.

5. Details of the wing venation and a description of the axillary sclerites are given.

6. The abdomen is spindle-shaped and consists of ten segments, although there appear to be only eight in the male and seven in the female.

7. The male and female genitalia are composed of the modified eighth, ninth, and tenth abdominal segments. The shape of the sacculus in the male genitalia is constant and is therefore useful in classification.

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STATISTICAL ADJUSTMENT OF DATA, by W. EDWARDS DEMING. Pages x and 261, 24 illustrations. Published by JOHN WILEY & SONS, INC., New York, 1943. Price $3.50.

This work by Dr. Deming of the Bureau of the Census and Bureau of the Budget, was developed over a period of 16 years in the Government service in assisting colleagues in many branches of science and as text material for classes taught in the Graduate School of the Department of Agriculture.

The scope of the volume is indicated by the section and chapter headings as follows: Part A—Some Simple Adjustments: Chapter I, On the Meaning of Adjustment; Chapter II, Simple Illustrations of Curve Fitting. Part B—The Least Squares Solution of More Complicated Problems: Chapter III, The Propagation of Error; Chapter IV, The General Problem in Least Squares. Part C—Conditions Without Parameters: Chapter V, Geometric Conditions; Chapter VI, Systematic Computation for Geometric Conditions; Chapter VII, Adjusting Sample Frequencies to Expected Marginal Totals. Part D—Conditions Containing Parameters; Chapter VIII, Curve Fitting in More Complicated Circumstances; Chapter IX, Systematic Computation for Fitting Curves by Least Squares. Part E—Exercises and Notes: Chapter X, Exercises on Fitting Various Functions; Chapter XI, Four Examples in Curve Fitting. Appendix—Tables for Making Random Obesrvations for Class Illustration: A, Normal Deviates Directly in Units of the Standard Error; B, Normal Distribution of the Numbers from 0000 to 9999.

The book gives rather more mathematical theory than some texts and the different topics are more generally unified under the basic principles. It is designed to supplement rather than to span other texts and seems excellent within the intended scope. Least squares and curve fitting are treated extensively and the book seems most useful as a text and reference in these fields because of the emphasis given to phases difficult to find elsewhere, such as curve fitting in the case where both the x and y values are subject to error, and other developments especially useful in conducting social and economic surveys by sampling. Some topics are not treated or are given only slight emphasis, and among these are the analysis of variance, covariance, experimental design, and plot techniques, with which many entomologists, and particularly those engaged in testing insecticides, are concerned.—F. H. HARRIES.

A CASE OF PARENTAL CARE IN THE HETEROPTERA

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Parental care is well known in certain insects with complete metamorphosis, especially the Hymenoptera, but it is not common in insects with incomplete metamorphosis, except in the Isoptera. The Dermaptera, Embiidina and a European mole cricket care for their young and are said to be incipiently social or subsocial. Kirkaldy (1903) summarizes the subject of parental care in non-social insects especially the Rhynchota. In the lace bugs (Tingitidae) groups of nymphs are frequently found with females on the under surfaces of their respective hosts, but associations of this sort are not cases of parental care; the nymphs and the adults are together only because the females continue to lay eggs over a comparatively long period.

The writers were surprised to discover a marked case of parental care in a species of Pentatomidae, *Meadorus lateralis* (Say)[1]. The nymphs of all pentatomids have a tendency to assemble immediately after the eggs hatch, but in few cases do the females remain with the eggs or brood over the nymphs. Several accounts of scutellerids that care for their young occur in European literature. Mr. H. G. Barber states (in correspondence) that while collecting in Puerto Rico in 1914 he observed a number of females of *Pachycoris fabricii* (L.) hovering over their young in much the same fashion as described by Kirkaldy for other scutellerids. As all of these accounts are meagre, the habits of *Meadorus lateralis* seem worth special mention.

Behavior.—This insect was first noticed on July 7, 1942. At that time numerous groups of unhatched eggs and many groups of first and second instar nymphs were found upon the under surfaces of the leaves and upon the cones of black birch (*Betula lenta*). The color of the nymphs resembles the feeding scars of squirrels and other animals on the cones, which made the location of the insects difficult. The nymphs were more often found on the older trees, especially those bearing cones, and were more common in the tops of the trees. Drake (1922) refers to their habit of occupying the tree tops and remarks that they were found in felling tall trees to obtain seed. He also states that the nymphs of several instars fed in groups. As a rule, however, only individuals from a single egg mass remain together. If they are disturbed, nymphs of different instars may become mixed and the female will brood over them. The nymphs remain together during their entire development. Fifth instar nymphs were found in conspicuous clusters upon the leaves

[1]This species occurs in literature under the generic names *Meadorus*, *Acanthosoma*, *Elasmucha*, *Clinocoris*, *Elasmostethus*, and *Edessa*. There is some doubt concerning the correct generic name for this species. Inasmuch as the standard texts on Hempitera and Heteroptera use *Meadorus*, we have used this name.

and upon the cones (figs. 4 and 5). They were evident enough to be seen at a distance of twenty or thirty feet from the ground.

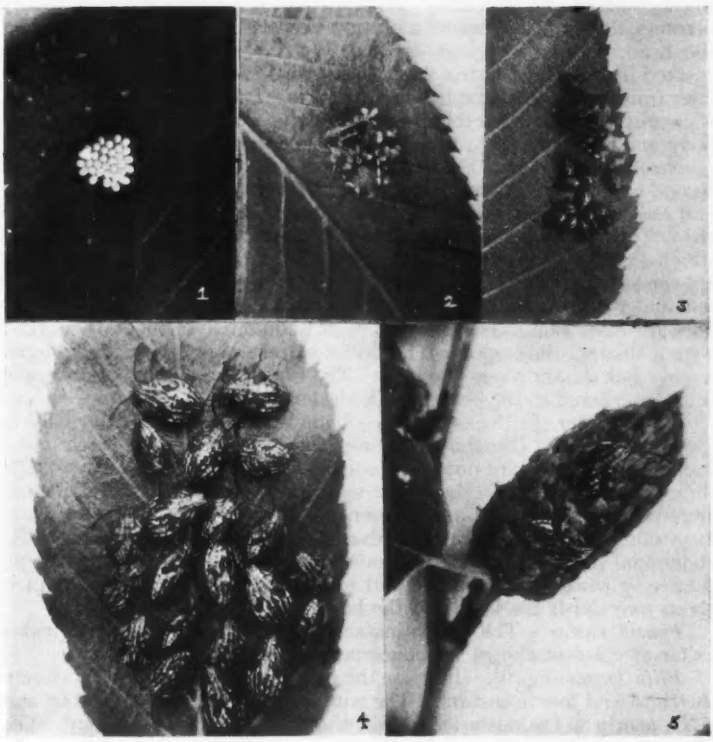
The development of this species is comparatively rapid. A batch of eggs laid in captivity on July 17 hatched on July 22. A trip to the woods on July 24 revealed that most of the first generation nymphs had reached the fourth or fifth instars. Adults from some of these nymphs emerged on July 25. Drake (1922) states that there are two generations a year. This is apparently correct for several mating pairs, and newly laid eggs were collected on July 24. On August 14 and 16 eggs, first and second instar nymphs were found in abundance.

Nymphs and adults are phytophagous, which explains why the nymphs can remain together for their complete development. The species apparently hibernates as adults.

The females were frequently found brooding over the eggs and younger nymphs (figs. 2 and 3). When they leave the nymphs is not exactly known; they were frequently seen with first, second, and third instar nymphs, but were not found with nymphs of the fourth and fifth instars. The brooding instinct is strong. The females resisted attempts to dislodge them from the leaves or from their young. As a matter of fact, some of the specimens were obtained from the tree tops by throwing sticks and stones at them. After the leaves fell to the ground, the females were invariably with their brood. If pushed from the side, the female tilts her body towards that side to protect the eggs or young. The claws of the female grip the leaf or the egg shells and she cannot be dislodged except with some difficulty. One female, deprived of her eggs, brooded over a dead male for five days. The female often vibrates her wings vigorously when disturbed. The instinct to congregate is also strong. The nymphs were observed to remain together during their entire development. Counts made on August 14th showed 46 first instar nymphs in a group, from 29 to 33 second instar nymphs grouped, and from 26 to 30 third instar nymphs grouped. Many nymphs no doubt fall prey to predacious species for they move rather slowly and the masses of nymphs are conspicuous. Predacious pentatomids have been observed attacking both adults and nymphs of *Meadorus*. Fourth and fifth instar nymphs were found in conspicuous groups usually in the tops of the trees.

Distribution.—Meadorus lateralis appears to have a northern distribution. According to Bueno (1939) it occurs from Quebec and the New England States to the Pacific coast. It does not occur south of New Jersey. In New York, Massachusetts, and Connecticut it has been reported as abundant and has been taken on yellow birch and beech. It is apparently locally common but generally scarce throughout most of its range.

The species has not been taken often in Pennsylvania. The following records are available: Inglenook, June 10, Knull; Laport, March 28 and June 3, Knull; Mt. Alto, June 3, Knull, July 27, Guyton; Sweden Valley, June 2, Knull; Chambersburg, May 28, Knull; Salisbury, Aug. 6, Guyton; Ohio Pyle, Aug. 5, Guyton; Nordmont, Aug., Pepper; South Fork Camp, Baker; Clarkes Valley, Champlain. From July 7 to August 30 the writers found the species common on black birch on Tussey Mountain near State College. The species was also found in



The birch pentatomid, *Meadorus lateralis* (Say). Figure 1. Eggs on birch leaf. 2. Female brooding over first instar nymphs. 3. Female brooding over second instar nymphs; female has been pushed to the side to reveal the nymphs. 4. Cluster of fifth stage nymphs on birch leaf. 5. Two fifth instar nymphs on birch cone.

nearby localities, especially wooded areas on the hilltops. Specimens were taken at Shingletown Gap, Keith Spring, and Bear Meadows.

Descriptions of stages.—Egg (fig. 1)—The eggs are white, exceedingly shiny and somewhat elongate. They are usually laid on the upper surfaces of the leaves of birch in groups of thirty or forty.

First Instar (fig. 6)—The nymph, shortly after hatching, is creamy white with indistinct reddish eyes and four indistinct reddish spots on the dorsum of the abdomen. With increasing age the color gradually becomes darker; just before moulting the eyes become dark red, and the head, thorax, and legs become gray. The head and thorax are marked by a narrow central white line, and there are two diagonal white lines from the base of the head to the eyes. The underside of the body is creamy white. The labium is about three quarters the length of the body and the legs and antennae are proportionally long.

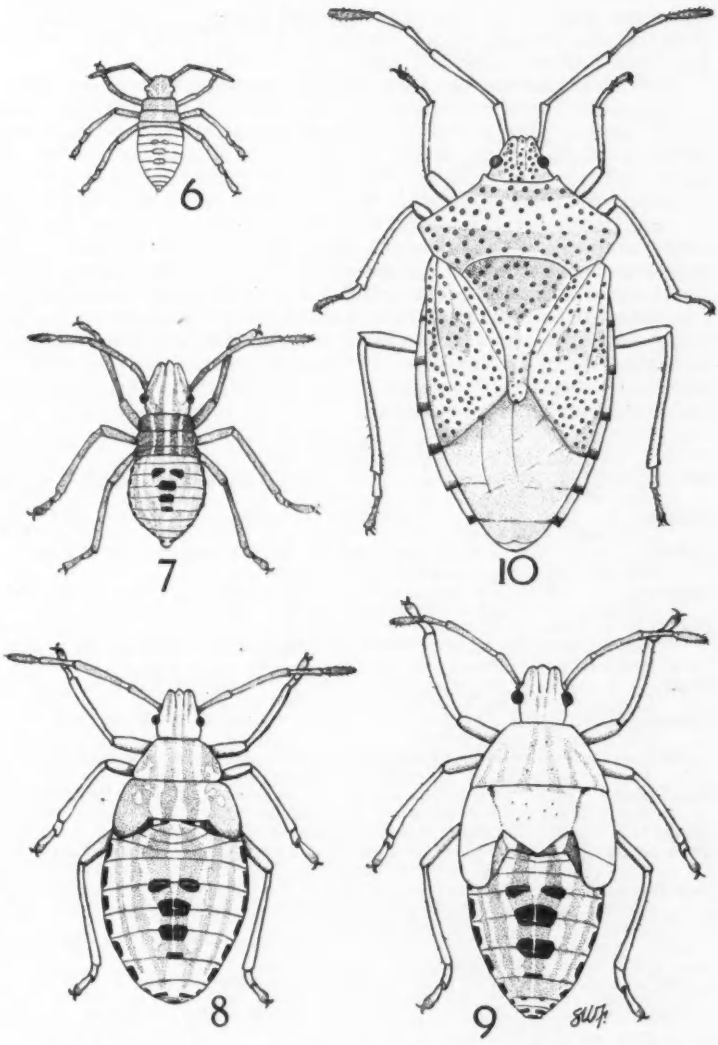
Second Instar (fig. 7).—The markings are more pronounced in the second instar. The dorsal surface of the head and thorax, the antennae and the legs are principally gray, although they may show a tinge of red. The thorax is marked by three narrow longitudinal white stripes which extend somewhat irregularly upon the head. The stink glands appear as five gray or brown spots on the dorsum of the abdomen. The remainder of the abdomen is red with a central white line and two white lines on each side. The edge of each abdominal segment is marked with a distinct dark spot. The under surface of the head and thorax is gray but darker along the sides. The under surface of the abdomen is cream-colored in the center and red along the sides.

Third Instar (fig. 8).—The wing buds begin to appear externally in the third instar. The thorax is brownish to pinkish with three longitudinal lines which are not as regular as those of the 2nd instar. The three white lines on the head are more pronounced. The abdomen is largely red. The dorsal aspect bears seven more or less distinct white longitudinal lines. The stink glands and the spots along the edge of the abdominal segments are conspicuous. The under surface of the nymph is creamy white in the middle and red along the sides. The labium is about two thirds the length of the body.

Fourth Instar.—The fourth instar is very similar to the third instar as far as color markings are concerned. It differs chiefly in size.

Fifth Instar (fig. 9).—In color the fifth instar resembles very closely the third and fourth instars. The wing pads are more conspicuous and reach nearly to the posterior edge of the third abdominal segment. The thorax is less distinctly colored than the preceding instar but the markings of the abdomen are similar. The labium is about two-thirds the length of the body. The antennae and legs are proportionally shorter.

Adult (fig. 10).—"Oblong-oval, subdepressed above, subconvex beneath. Above greenish yellow, rather evenly, not thickly marked with coarse reddish-brown punctures; antennae reddish-yellow, the tip of the last joint blackish; elytra with 2 vague reddish-brown or pale fuscous cross-bars; connexivum yellow, with an oblong blackish spot on each incisure; tergum reddish; under surface pale yellow, the punctures darker; legs reddish yellow. Cheeks sparsely unevenly punctate; tylus almost smooth, its front half widened and with a median groove. Pronotum with front portion unevenly punctate, the smooth



Life stages of *Meadorus lateralis* (Say). Figure 6. First instar nymph. 7. Second instar nymph. 8. Third instar nymph. 9. Fifth instar nymph. 10. Adult.

areas irregular and transverse; hind portion evenly and coarsely punctate. Scutellum very coarsely and sparsely punctate; elytra more finely and rather closely so. Abdomen with minute distant punctures, those of the thoracic pleura coarser. Length, 7.5–8.5 mm.; width, 4.5–5 mm." (After Blatchley, 1926.)

The Acanthosomatinae, including the genera *Meadorus* and *Elasmothethus*, are characterized by the two-segmented tarsi and a distinct ventral carina. The carina of *Meadorus lateralis* (Say) consists of two portions, a keel on the thorax terminating in a backward projecting spine, and a similar keel on the abdomen terminating in a forward projecting spine. The terminal spines of these two carinae overlap in the area between the mid and hind coxae. The tip of the thoracic carina is always to the left of the tip of the abdominal carina. When the thorax bends these terminal spines slip by one another. The thoracic carina is distinct for its entire length. It is fused along the meta- and mesothorax but the anterior end is free and projects over the prothorax, fitting into a groove in the cephalic margin of the prosternum. The abdominal carina is distinct on the anterior portion but is indistinct posteriorly, although it reaches to the genital cleft. The labrum is always held to the left of these carinae.

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THE EXTERNAL MORPHOLOGY OF THE OBLONG-WINGED KATYDID, AMBLYCORYPHA OBLONGIFOLIA (DeGEER)

(Orthoptera, Tettigoniidae)[1]

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This study has been undertaken for the purpose of providing a detailed account of the external morphology of a phaneropterine insect of the family Tettigoniidae, order Orthoptera. Although a few isolated accounts of portions of such insects are available, no complete and comprehensive study of the morphology of an insect belonging to the subfamily Phaneropterinae has been made. Information on the external morphology of this insect should give the student of phylogeny a clearer understanding of the phylogenetic position of the group, and indicate to the taxonomist the structures that are significant in classification. It should also provide a morphological basis for future studies and observations on the singing mechanism of these insects.

The members of the subfamily Phaneropterinae are commonly known as the "false katydids," in contradistinction to the closely allied subfamily Pseudophyllinae which are designated as the "true katydids." One of the characteristics of the Phaneropterinae which distinguish them from the Pseudophyllinae is that the hind wings are longer than the tegmina, whereas in the Pseudophyllinae the hind wings are shorter than the tegmina. Although the members of the Phaneropterinae produce a definite call, their sound hardly resembles the familiar "katy did, she did, she didn't," and it should be noted that it was the song of one of the true katydids (Pseudophyllinae) which gave rise to the common name for the group.

The species *Amblycorypha oblongifolia* (DeGeer) is a typical representative of the Phaneropterinae, with a wide range. According to Blatchley (1920) the known range of this species is "from New England and Montreal west to southwestern Ontario, Michigan, Minnesota and Colorado, and south and southwest to Maryland, North Carolina,

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[1]This study was undertaken at the suggestion of Dr. G. C. Crampton. The writer is deeply indebted to him for his valuable advice and criticism throughout the progress of this study, and for the specimens which he was kind enough to supply.

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Appreciation and thanks are due Miss Ruth Keller who was kind enough to type the original manuscript, and to Dr. A. B. Gurney, formerly of the National Museum, who determined the species under consideration as *Amblycorypha oblongifolia* (DeGeer).

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Alabama, Louisiana and Texas." Thus it might easily be made available for class study in morphology, and its size and the primitive structure of many of its parts would give the beginning student in morphology a sound basis for understanding the more specialized structures found in the members of higher Pterygotan orders.

The members of the genus *Amblycorypha* Stål are commonly known as the "round-headed katydids," and *A. oblongifolia* is specifically known as the Oblong-winged Katydid. The following description of the species is taken from Blatchley:

> "Size large for the genus; form robust. General color a bright pea-green, the shrilling organ of male brownish, with a heavy green crossvein; abdomen and usually the fore and middle femora, yellowish or brownish green; hind femora often brownish-yellow. Disk of pronotum with sides distinctly divergent on basal two-thirds, subparallel with lateral carinae less distinct on apical third; humeral sinus well impressed; hind margin of lateral lobes broadly rounded. Tegmina elongate-elliptical, about 3.3 times as long as wide. Wings in repose surpassing tegmina six or more mm. Hind femora very slender, usually scarcely reaching tip of tegmina, female, distinctly shorter, male, their inner lower carina armed with six to twelve rather strong teeth.
>
> "Length of body, ♂, 21–23, of ♀, 22–25; of pronotum, ♂, 6–6.5, ♀, 7; of tegmina, ♂, 36–36, ♀, 35–37; of posterior femora, ♂ and ♀, 30–31; of ovipositor, 11.5–13 mm. Width of tegmina, 11–12 mm."

THE HEAD

Figures 1-8, 11

The head of *A. oblongifolia* is of the hypognathous type. Viewed from the front the head capsule and mouthparts are elongate-oval in outline (fig. 1), and under alcohol the surface appears smoothly polished.

Head Capsule.—The frons (*fr*) is a conspicuous area on the anterior portion of the epicranium.[2] Its limits, however, are not very clearly defined. When viewed exteriorly it appears to merge with the clypeus (*clp*) beneath it. Internally, however, there is a slight ridge (shown in fig. 1 by a dotted line) extending between the anterior tentorial pits (*atp*) demarking its lower limits. The upper limits of the frons are demarked by the lower mesal margins of the eyes, the basal and mesal margins of the antennal sclerites (*asc*) and the anterior margin of the fastigium (*fst*). The small dotted area (*ma*) in the upper portion of the frons represents a conspicuous muscle attachment. Laterally the frons merges with the genae (*ge*) on each side of the head.

The genae are demarked ventrally by the subgenal sutures (*sgs*), dorsally by the temporal sutures (*ts*), and posteriorly by the postgenal sutures (*pgs*), while the posterior margin of the eyes and the frons demark the anterior limits. Those portions of the genal areas behind the eyes and immediately beneath the temporal sutures, are sometimes designated as the tempora (*te*). Beneath the subgenal sutures are

[2]The term "epicranium" is here used to designate the paired areas of the head and the frons, but not including the clypeus.

the subgenae (*sge*), variously called the basimandibulare and trochantin of the mandible. The postgenae (*pge*) lie behind the genae, from which they are separated by the postgenal sutures, while the postoccipital sutures (*pos*) demark their posterior limits.

The dorsal portion of the head capsule is the vertex (*vx*), a flattened anterior projection of which is set off as the fastigium (*fst*). No coronal suture is present to divide the vertex into two areas as is frequently the case in lower Pterygota. Likewise there is no occipital suture present which usually divides off the posterior region of the vertex into an occipital area, and such an area can only roughly be defined as the posterior region of the vertex.

When the head is removed and viewed from the rear (fig. 2) a large opening called the occipital foramen (*ocf*) is plainly visible. Surrounding this opening laterally and dorsally is a narrow sclerite, the postocciput (*poc*), to the posterior margin of which the cervical membrane (*cm*) is attached. This sclerite is separated from the remainder of the epicranium by the postoccipital suture (*pos*), and is shown in fig. 2 in internal view since it is bent back upon the head capsule. A small portion of the posterior margin of the postocciput is produced on each side into a small, cup-like process, the occipital condyle (*oc*), to which is articulated the cervical sclerite (*lc*), (fig. 6).

Tentorial Pits (figs. 1 and 6).—Lying at the mesal extremity of each subgenal suture are the slit-like invaginations called the anterior tentorial pits (*atp*), sometimes termed the frontal pits; lying at the back of the head, between the postocciput and the postgenae at the ventral ends of the postoccipital sutures, are the prominent, elongated invaginations, the posterior tentorial pits (*ptp*), sometimes called the gular pits. Since there is no definite gular region in this form, however, the term "posterior tentorial pit" is preferable to "gular pit," and for sake of uniformity the term "anterior tentorial pit" is preferable, in this case, to "frontal pit."

Eyes.—The compound eyes (*e*) are conspicuous elongate-oval structures, projecting from the upper lateral portions of the head capsule. The number of facets in each compound eye approximates fifteen hundred. Ocelli are lacking.

Antennae (figs. 1 and 3).—The antennae, located next to the lower mesal margin of the eyes, are filiform in structure. They measure about 40 mm. in length and average between 160–170 segments. The basal segment of the antenna, or scape (*scp*), is roughly cylindrical and about twice as long as it is wide. Laterally its base is extended into a finger-like pivoting process (*ap*), while mesally its base is rounded into a ball-shaped structure (*bsc*). The second segment of the antenna, or pedicel (*pdc*), is separated from the scape by a narrow circular membrane, within which it hinges. The pedicel is closely joined to the succeeding postpedicel (*ppd*), which represents the first segment of the flagellum of the antenna.

The base of the antenna is surrounded by an annular portion of the integement, known as the antennal sclerite (*asc*). It bears a projection near the base of the antenna termed the antennifer (*af*). Fig. 1 shows the antennal articulating area (*aar*), left by the removal of the left

antenna, to be a relatively small one. The remainder of the membranous area within the antennal sclerite serves as an antennal socket (*aso*) for the swivel action of the ball of the scape (*bsc*), while the antenifer serves as a pivotal structure for the pivoting action of the antennal pivot (*ap*). This combination gives the insect considerable freedom for forward, backward and rotating movements of its antennae.

Clypeus and Labrum (fig. 1).—The clypeus (*clp*) is a trapezoidal sclerite hanging by its longer base from the epicranium. Two narrow projections of its upper base merge laterally with the subgenae. There is no epistomal suture extending between the anterior tentorial pits to demark the clypeus from the frons.

The labrum (*lr*), attached to the lower base of the clypeus, is horseshoe-shaped in outline. There is no suture between the clypeus and labrum. The boundary between the clypeus and labrum is demarked on the oral, or pharyngeal, surface by the tormae (*to*), to be described below.

Epipharynx (fig. 5).—The epipharynx is a median lobe present on the posterior oral surface of the labrum and clypeus. It may be divided into a preepipharynx (*pre*) and a postepipharynx (*poe*), found on the oral surfaces of the labrum and clypeus respectively. In the lateral angles between the clypeus and labrum there are thickenings, or ridges, termed tormae (*to*). These thickenings continue, somewhat less strongly, into the epipharyngeal region, and thus serve to demark the preepipharynx from the postepipharynx, as well as to demark the labrum from the clypeus.

Mandible (fig. 4).—The endognath (*eg*) is a basal internal shelf projecting inward and extending around the triangular basal portion of the mandible. Each of the sides of the triangle represents the base of one of the three surfaces of the mandible. There is an outer or lateral surface, and an anterior and posterior surface. The edges of the latter two surfaces meet mesally to form the gnathal edge of the mandible. The gnathal edge is divided into a distal or apical incisor region (*in*), used for tearing the food apart; an intermediate grinding region, or mola (*m*); and a basal region containing stiff, elongate bristles, termed the brush (*br*), or brustia.

The epignath (*epg*) is a lateral prominence borne basally by the outer or lateral surface, to which the extensor tendon (*et*), of the muscles which open the mandible, is attached. At the base of the gnathal edge of the mandible is the gnathite (*gn*), which bears the flexor tendon (*ft*) to which are attached the muscles which close the mandible.

The posterior surface of the mandible bears a condyle (*co*) basally. When the mandible is viewed in position (fig. 2) it will be seen that the condyle articulates with a cup-shaped structure, the postgenal

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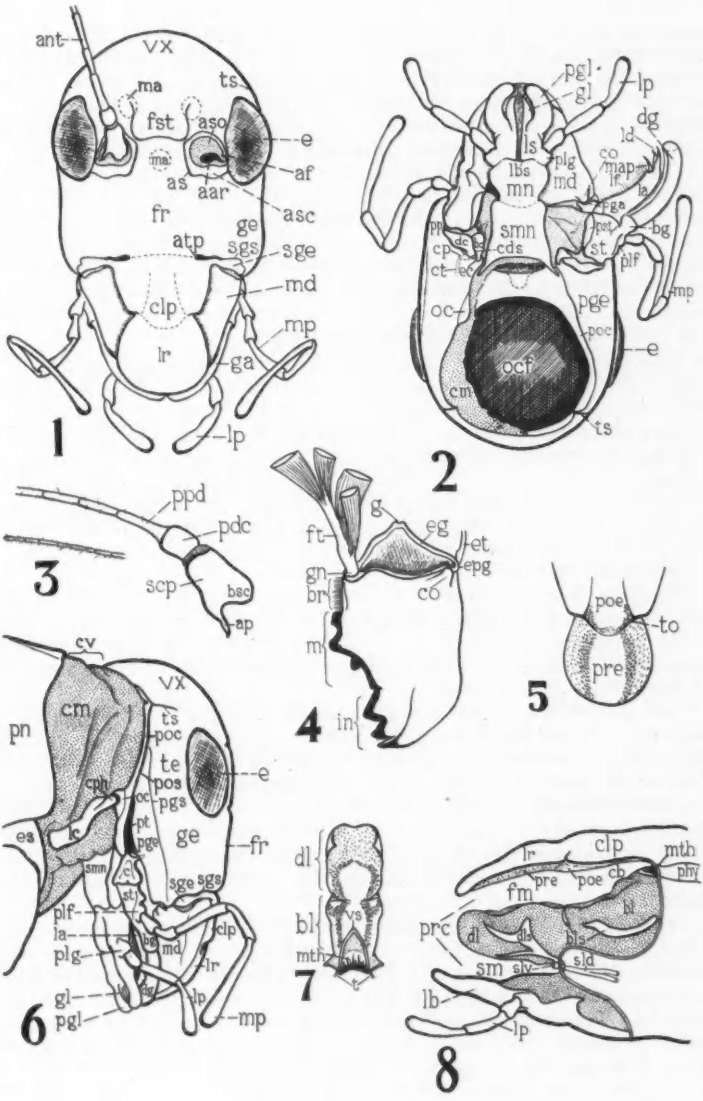
EXPLANATION OF PLATE I

Head and associated structures of *Amblycorypha oblongifolia* (DeGeer). Figure 1. Anterior view of head. 2. Posterior view of head. 3. Basal and distal segments of antenna. 4. Posterior view of right mandible. 5. Under surface of labrum, showing epipharynx. 6. Postero-lateral view of head and cervix. 7. Dorsal, or anterior, view of hypopharynx. 8. Lateral view of mouth cavity.

(For explanation of abbreviations see pp. 190–92.)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acetabulum (*pga*), sometimes termed the postgenotheca, which is borne by the postgenal process (*pp*). The ginglymus (*g*) is a cup-shaped structure borne in an anterior projection, or pivoting point, which is itself borne basally by the anterior surface of the mandible. This process fits into a niche formed at the postero-lateral angle of the clypeus. The ginglymus, or cup-shaped structure within this process, itself receives a projection of the clypeal angle, and thus this process both projects and receives an articulating or pivoting point.

The extensor muscles attached to the extensor tendon exert a pull laterad of the articulating points, causing the mandible to open; while the flexor muscles attached to the flexor tendon exert a pull mesad of the articulating points and cause the mandible to close. The large size of the flexor tendon and the large muscles attached to it, adapt the insect mandible for the powerful crushing action of the closing mandible, whereas for the lesser task of merely opening the mandible a smaller tendon with small muscle attachments suffices.

Maxilla (fig. 2).—The basal segment of the maxilla is the cardo (*c*). This is divided by the cardinal suture (*cds*) into a basicardo (*bc*) and a *disticardo* (*dc*). The basicardo bears a saddle-shaped articulating process proximally, which is composed of an internal cardinal process (*cp*) and an external epicardo (*ec*). To the internal cardinal process a cardinal tendon (*ct*) is attached. The contraction of the muscles attached to this tendon causes the "saddle," formed by the internal cardinal process and the external epicardo, to ride or pivot over a niched ridge, sometimes termed the postoccipital process, beneath it (or actually dorsal to it).

Ventrad of the cardo is the maxillary stipes (*st*). Lying next to the stipes mesally, and separated from it by the parastipital suture (*psts*), is the parastipes (*pst*). The parastipital suture is the external manifestation of an internal ridge, or endostipes, to which the flexor muscles of the maxilla are attached.

Laterad of the stipes lies the palpifer (*plf*), a faintly demarked area which bears the five-segmented maxillary palpus (*mp*). Distally the stipes bears two lobes, a mesal lacinia (*la*) and an outer galea (*ga*). The lacinia bears a lacinial fringe (*lf*) along its inner margin and two tooth-like processes termed the lacinio-dentes (*ld*) at its apex, while just proximad of the lacinio-dentes is a moveable spine-like appendage called the midappendix (*map*). The galea is composed of two segments, a basigalea (*bg*) and a distigalea (*dg*), the latter partly concealing the lacinia.

Labium (fig. 2).—The labium or under lip is divided into a movable distal prelabium and a basal postlabium. The postlabium is a well sclerotized area composed of a distal mentum (*mn*) and a proximal submentum (*smn*), which is faintly, if at all, demarked from the mentum before it. The proximal angles of the submentum are closely associated with the ventral ends of the postocciput, and in this connection the latter is sometimes termed the trophifer.

The mentum is separated from the prelabium by the labial suture (*lbs*). The basal segments of the prelabium are composed of the labial stipites (*lst*) while laterad of the stipites are the palpigers (*plg*), which

bear the three-segmented labial palpi (*lp*). Distally the labial stipites bear the mesal lance-shaped glossae, and the outer fleshy paraglossae.

Hypopharynx (figs. 7 and 8).—The hypopharynx is composed of a distal region, or distilingua (*dl*), and a basal region, or basilingua (*bl*). The distal lobe of the hypopharynx is strengthened on each side by the distilingual sclerites (*dls*), each of which sends a narrow arm proximally to the opening of the salivary duct (*sld*), while the basal lobe is strengthened on each side by the presence of the basilingual sclerite (*bls*). The basilingual sclerite, which is a single continuous sclerite in the roach as shown by Crampton (1925), is separated in the present species into a relatively large basal sclerite and a small, narrow, distal sclerite, the latter demarking the distilingua from the basilingua. A narrow V-shaped sclerite (*vs*) borders the mouth opening anteriorly, and its arms continue internally to form a pair of tendons (*t*) for muscle attachment (fig. 7).

According to Snodgrass the cavity in which the hypopharynx lies is the preoral cavity (*prc*). That portion of the cavity between the hypopharynx and the epipharyngeal region is known as the food meatus (*fm*), while posteriorly between the hypopharynx and the inner surface of the labium lies the salivary meatus (*sm*). The proximal region of the food meatus is termed the cibarium (*cb*) and leads into the true mouth (*mth*), which in turn leads into the pharynx region (*phy*) of the gut. The salivary meatus contains in its proximal portion a small sclerotized region termed the salivarium (*slv*), into which the salivary duct empties.

Tentorium (fig. 11).—Fig. 11 is a posterior view of the head capsule showing the tentorium. Invaginations from the anterior tentorial pits (*atp*) extend posteriorly to form the anterior arms (*at*) of the tentorium, while invaginations from the posterior tentorial pits (*ptp*) extend anteromesally to form the posterior arms (*pt*). Where the fused posterior arms unite with the fused anterior arms, the corporotentorium (*cpt*), or eutentorium, is formed. A niche, or neuroforamen (*nf*), found anterior of the eutentorium, permits the circumoesophageal connectives to pass through from the brain to the suboesophageal ganglion. A furca-like invagination (*tf*) in the posterior portion of the corporotentorium, where the posterior arms unite, probably serves to give additional strength to the tentorium. No dorsal arms of the tentorium are present.

THE THORAX

Neck Region (fig. 6).—Although the neck region, or cervix (*cv*), is here taken up with the thorax, it should be remembered, as Snodgrass, Crampton and others have suggested, that the neck is probably derived from portions of both the labial and prothoracic segments. The greater part of the cervix consists of the cervical membrane (*cm*) which bears on each side a lateral cervical sclerite (*lc*). The anterior portion of each lateral cervicale is differentiated into a knob-like cephaliger (*cph*), which articulates with the occipital condyle of the head, while the posterior portion articulates with a membranous fold just anterior to the episternum (*es*).

PROTHORAX

Pronotum (fig. 22).—The pronotum (*pn*) is a saddle-shaped structure which covers the prothorax dorsally and laterally. The upper, dorsal surface is termed the disc (*dsc*), while the lateral portions are called the lateral lobes (*ll*). Each lateral lobe has overgrown most of the episternum (es_1) and the epimeron (ep_1), but while it has fused with the greater portion of the latter it has fused only marginally with the episternum. Dorsally the rounded posterior portion of the disc partially covers the scutum of the mesothorax. The surface of the pronotum is smooth, but each lateral lobe contains two pronotal sutures, or sulci (*su*), the anterior of which is continued into the region of the disc.

Propleuron (fig. 22).—Only a small ventral portion of the pleuron is visible just below the rounded, marginal edge of the lateral lobe of the pronotum. It is demarked by the pleural suture (pls_1) into an anterior episternum (es_1), and a posterior epimeron (ep_1). A narrow portion of both the episternum and epimeron continues downward along the pleural suture to form a pleural articulation (*a*) for the coxa (*cx*).

Under the lateral lobe of the pronotum is a thin sclerotic continuation of the episternum, while the major portion of the epimeron has become fused with the pronotum. A narrow, thick sclerotization of the epimeron continues upward along the furrow formed by the pleural suture. The extent of these areas beneath the lateral lobe of the pronotum is shown in fig. 22, by broken lines. The above substantiates the view of Crampton, and Duporte, that in the Orthoptera the pronotum has overgrown the pleuron, rather than that the pronotum has forced out the pleuron as some investigators would have us believe.

The region extending downward from the episternum (fig. 13) anterior to the coxa and the trochantin (tn_1), and united ventrally with the sternum, is the precoxal bridge or precoxale (pcx_1), while the narrow sclerite behind the coxa which unites ventrally with the sternum and dorsally with the peritreme (*ptr*) of the first thoracic spiracle, is the postcoxal bridge, or postcoxale ($pocx_1$).

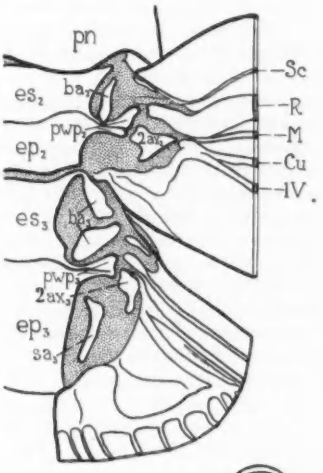
The trochantin (tn_1) is a small sclerite forming a point of articulation for the leg (*b*), between the precoxale and the coxa.

Fore Leg.—The fore leg is shown in fig. 17, while its articulation with the pleuron can best be seen in fig. 22. The proximal leg segment, or coxa (*cx*), articulates with the pleural leg process (*plp*) at *a* and with the trochantin at *b* (fig. 13). A coxal spine (*cxsp*) is borne by the coxa just beneath the pleural articulation. The meron (*mr*) is represented by a small area. A more detailed discussion of the morphology of the coxa will be taken up under the discussion of the hind leg.

EXPLANATION OF PLATE II

Amblycorypha oblongifolia (De Geer). Figure 9. Ventral view of left wing bases. 10. Dorsal view of mesothorax and metathorax, with right wing bases. 11. Posterior view of head capsule, with mouthparts removed, showing tentorium. 12. Ventral view of vannal area of left wing of male, showing file of rasping vein. 13. Ventral view of thorax. 14. Dorsal view of vannal areas of tegmina of male, showing stridulating mechanism.

(For explanation of abbreviations see pp. 190–92.)



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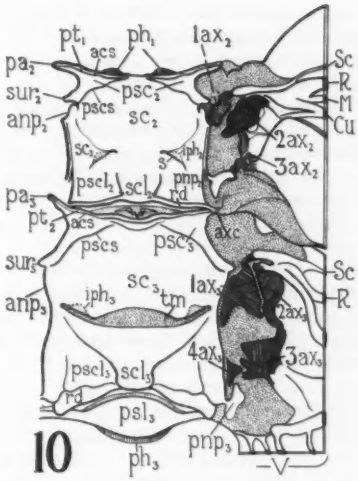

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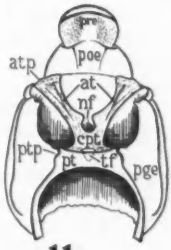

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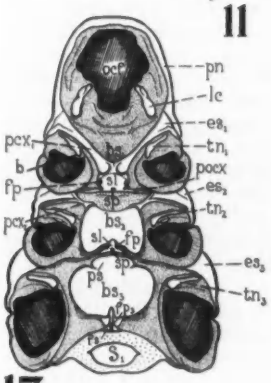

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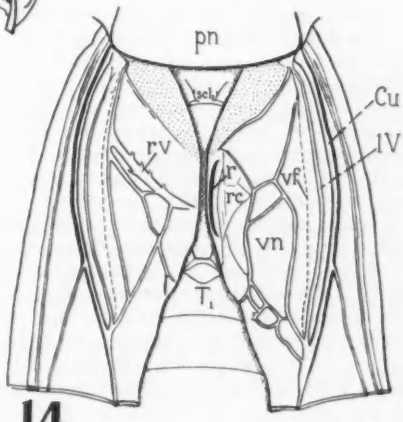

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The coxa is followed distally by the trochanter (*tr*), with which it articulates at points *d* and *d'* (fig. 22). The trochanter is firmly joined to the femur (*fem*), which is a comparatively stout segment, slightly grooved beneath, the anterior marginal edge of the groove being armed with a number of spines.

The tibia (*ti*) is almost square in cross-section and each margin is well armed with spurs, which are movable processes, in contrast to the spines of the femur which are immovable. The proximal portion of the tibia is somewhat flatter and considerably broader than the remainder of the segment, and contains the so-called ear, or auditory organ (*ao*), of the katydid. The external structure of the auditory organ is shown enlarged in fig. 21. It consists of an oval cavity on each side of the tibial segment, while the surface of the cavity is composed of a membrane (*me*) containing a thin, elongate-oval sclerite (*tym*). The internal surface of each area on opposite sides of the tibia become approximated and these structures act like drums to receive vibrations which are transmitted to chordotonal sensillae within the tibia.

The four-segmented tarsus (*ta*) is almost identical in the fore, middle, and hing legs, and the description which follows may serve for all of them. The segmental subdivisions of the tarsus may be termed the tarsomeres (*tsm*), and are best seen in fig. 19 of the hind leg. The basal tarsomere, sometimes distinguished as the basitarsus (*bts*) is subequal in length to the fourth tarsomere, or distitarsus (*dts*). The ventral surface of the basitarsus consists of a proximal, bilobed, pad-like structure, or pulvillus, followed by a single, distal pulvillus, and therefore it is not at all unlikely that the apparent basitarsus consists of two fused tarsomeres. The second tarsomere is the smallest, while the third tarsomere is distinctly bilobed and broader than the others. Both bear pulvilli. The fourth tarsomere, or distitarsus, is cylindrical and lacks pulvilli.

The claws, or ungues (*ung*), are borne by a distinct segment, which is homologous with the dactylopodite of the crustacean limb. The term pretarsus has been used to designate this segment in insects, but this term is decidedly inaccurate since it implies a segment lying basad of the true tarsus, rather than distad of it. Even the term dactylopodite would be preferable to pretarsus, but this former term is cumbersome and properly implies the distal segment of a crustacean limb. Although a concise descriptive term is desirable, there is no gain in sacrificing clarity for brevity. Therefore it is suggested that the term posttarsus be used to designate this distal segment, since such a term is both accurate and descriptive, and not unwieldly.

An enlarged view of the posttarsus (*psta*) is seen in ventral view in fig. 20. The posttarsus bears a pair of lateral claws, or ungues. Each claw articulates dorsally to a median process at the apical end of the distitarsus, termed the unguifer (*unf*), shown in fig. 19. On the ventral surface of the posttarsus is a median plate, the unguitractor (*utr*), which lies in part beneath the disto-ventral sclerotization of the distitarsus. To its proximal end is attached the tendon-like apodeme called the retractor of the claws (*t*), on which, according to Snodgrass, is inserted the depressor muscle of the posttarsus.

Prosternum.—A ventral view of the thorax (fig. 13) shows the greater part of the prosternum to consist of the sternellum (*sl*), containing the furcal pits (*fp*) laterally which invaginate to give rise to the furca, internal processes serving for muscle attachment, while on the posterior portion is borne the spinal pit (*sp*), which invaginates to form the spina, which likewise serves for muscle attachment. The term sternellum is here used to designate the combined furcasternum and spinasternum, as used by Crampton, although it should be noted that Snodgrass uses the term sternellum as synonymous with furcasternum alone.

The basisternum (bs_1) is reduced to a small area between the ventral extremities of the precoxal bridges.

MESOTHORAX

Although the mesothorax is somewhat smaller than the metathorax and is functionally less active, since neither leaping legs nor active flight organs are present, the parts of the mesothorax exhibit a complexity almost equal to that of the metathorax.

Mesonotum (fig. 10).—In the anterior region of the mesonotum is a narrow, marginal region termed the pretergite (pt_1). The pretergite is separated from the prescutum (psc_2) immediately behind by the antecostal suture (*acs*) representing the true intersegmental boundary, which gives rise internally to a pair of small inflections, or lobes, termed the first phragma (ph_1), which serve for the attachment of the dorsal longitudinal muscles. The prescutum of Snodgrass is separated by the prescutal suture (*pscs*) from the large scutal area, or scutum (*sc*), which follows. The scutum contains a pair of secondary sutures (*s*), each of which bears internally a lobe-like inflection termed the interphragma (*iph*). The posterior region of this tergal plate is occupied by the scutellum (*scl*), which is flanked on either side by a depressed area called the parascutellum ($pscl_2$) by Crampton. It should be noted, however, that these parascutellar areas actually represent a posterior portion of the scutum. The posterior margin of the scutellum folds under itself to form a reduplication (*rd*).

Along the side of the mesonotum are found several lateral projections, some of which are involved in the movements of flight and in the stridulating movements. The anterior of these projections is the prealare (pa_2), which is formed from both pretergite and prescutum, while behind this projection lies the suralare (sur_2) which juts out toward the neck of the first axillary ($1ax_2$) and aids in the anterior articulation of the wing. Following the suralare is the anterior notal wing process (anp_2) which abuts against the body of the first axillary, while the posterior notal wing process (*pnp*) abuts against the third axillary ($3ax_2$). The reduplication (*rd*) extends laterally into the thickened, membranous axillary cord (*axc*).

Pteralia (fig. 10).—Although the wing articulates with the tergal region of the thorax by a membranous basal area, there are present in this area a number of articular sclerites which are collectively termed the pteralia. The first of these articular sclerites, the first axillary ($1ax_2$), articulates mesally with the anterior notal wing process and suralare, and articulates laterally with the second axillary ($2ax_2$), while an anterior

neck-like projection of the first axillary abuts against the base of the subcostal vein (*Sc*). The second axillary abuts against the common base of the radial and medial veins (*R* and *M*) anteriorly, while posteriorly it articulates with the anterior projection of the third axillary ($3ax_2$). The third axillary forms the posterior wing articulation with the posterior notal wing process (pnp_2).

Fore Wing (fig. 16).—The fore wing is elongate-oval in outline, and is termed the tegmen. Numerous cross-venules (not shown) give it a thickened leathery texture.

No distinct costal vein was found to arise from the basal trunk. The subcosta (*Sc*), whose base abuts against the neck of the first axillary, runs for a short distance and then branches to merge with the numerous venules. The radius (*R*) continues as a single vein with no branches to the apical margin of the wing, while the media (*M*) is four-branched. The cubitus (*Cu*) divides proximally into two branches, the anterior branch dividing into a number of sub-branches, while the posterior branch runs along the hind margin of the wing and meets the anterior sub-branches. The first anal vein, or vannal vein (*1 V*) of Snodgrass is prominent. Immediately behind the first vannal vein is the vannal fold (*vf*) which divides the tegmen into a large anterior remigial region (*rm*), and a relatively small posterior vannal region (*vn*) which folds over the tergum of the thorax.

When the tegmina are folded in place, their color and the position of the veins might readily lead to their being mistaken for the color and venation of a leaf.

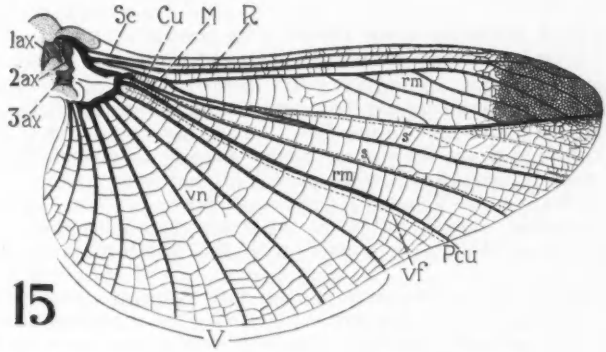
Stridulating Mechanism (figs. 12 and 14).—The vannal region of the fore wings of the male katydid bears the stridulating mechanism. The vannus of the left wing almost invariably folds over the vannus of the right wing. Submarginally the right vannus bears a dorsal rasp (*r*), or knife-edged sclerotization. Laterad, or actually anterior, of this rasp the surface of the wing contains a concave area which acts as a resonating chamber (*rc*). The vannus of the left wing bears a rasping vein (*rv*), which is seen in fig. 12 to bear a file-like sclerotization ventrally, which may be termed the file (*f*). As the fore wings are expanded and brought back into place, the rasp (*r*) on the dorsal surface of the right wing moves along the file (*f*) on the ventral surface of the left wing, producing the stridulation which is amplified and resonated by the resonating chamber (*rc*) located in the right wing.

Alaria.—Fig. 9 shows the ventral articulation of the wing base with the pleuron. There are usually present in this area a number of small sclerites which serve for the insertion of important wing muscles, termed the alaria by Crampton. These sclerites are the epipleurites of Snodgrass.

EXPLANATION OF PLATE III

Wing and leg structures of *Amblycorypha oblongifolia* (De Geer). Figure 15. Hind wing of female. 16. Fore wing of female. 17. Fore leg. 18. Middle leg. 19. Hind leg. 20. Ventral view of posttarsus of hind leg. 21. Enlarged view of "ear" of fore leg.

(For explanation of abbreviations see pp. 190–92.)



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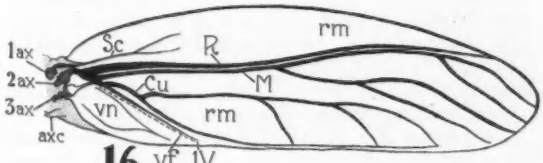

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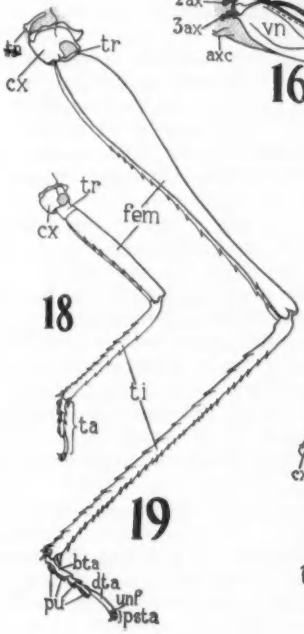

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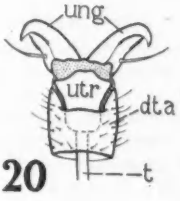

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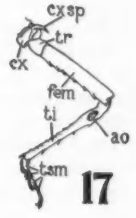

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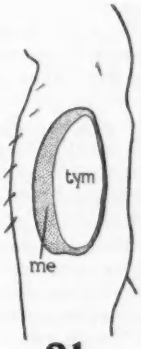

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Anterior to the pleural wing process (pwp_2) is the basalare (ba_2), while above the pleural wing process is the intralare ($2ax_2$) of Crampton which represents the ventral sclerotization of the second axillary. This latter sclerite pivots upon the pleural wing process in the movement of the tegmina. No subalare sclerite is present in the mesothorax.

Mesopleuron (figs. 13 and 22).—The major portion of the pleuron is occupied by the episternum (es_2) and the epimeron (ep_2) which are separated by the pleural suture (pls_2). The episternum and the epimeron continue along the pleural suture dorsally to give rise to the pleural wing process (pwp_2), while their continuation along the pleural suture ventrally forms the pleural leg process (plp_2).

The anterior ventral portion of the episternum joins the narrow precoxale (pcx_2), the latter joining with the basisternum ventrally (fig. 13).

Anterior to the episternum, in the intersegmental membranous area, is a large cavity which is partly covered by the pronotum (fig. 22). At the lower anterior margin of this large cavity is a much smaller spiracular opening. These two openings together constitute the double, first thoracic spiracle (spi_2) which properly belongs to the mesothorax. The larger of these openings sends off a large tracheal branch into the fore leg, while the smaller of these openings sends off a small tracheal branch into the body cavity. This double spiracle is located in a sclerotized area termed the peritreme (*ptr*).

Snodgrass has shown that the first thoracic spiracle in *Dissosteira* has a corresponding double tracheation, and therefore gives the appearance outwardly of an apparent double opening. In the katydid the posterior of these openings has become greatly developed and specialized into an "accoustic" trachea with its own separate opening, so that the apparent double spiracular opening of *Dissosteira* has become in actuality a double opening in *Amblycorypha*.

Middle Leg (fig. 18).—The mesothoracic leg is slightly larger than the fore leg, and except for the absence of an auditory organ is similar to the fore leg.

No coxal spine, however, is present on the coxa (cx_2) of the middle leg and the meron (*mr*) is somewhat more developed than that of the fore leg. The coxa articulates with the short trochanter (*tr*), which is joined to the femur (*fem*). The femur is grooved beneath and the outer edge of the groove is armed with spines. Following the femur, and slightly longer than it, is the tibia (*ti*). The tibia is square in cross-section and each of its four edges is armed with spurs. The four-segmented tarsus (*ta*) and the posttarsus (*psta*) are almost identical with those of the fore leg.

Mesosternum (fig. 13).—The greater portion of the sternal sclerotization is occupied by the basisternum (bs_2). The basisternum is considerably depressed medially, the lateral edges being raised above the surrounding membranous area, while its posterior lobes jut back toward the metasternum. Lying below the plane of the basisternum, and at an angle to it, is the sternellum (sl_2), which is the furcasternum and spinasternum combined. The sternellum bears the furcal pits (fp_2), each of which gives rise to an internal furca, or apophysis, and the spinal

pit (sp_2) which invaginates internally into a pair of narrow lateral arms and a pair of short, posterior, horn-like arms, collectively making up the spina.

METATHORAX

Correlated with the presence of large jumping legs and active organs of flight, the metathorax is the largest and most highly developed of the thoracic segments.

Metanotum (figs. 10 and 22).—The narrow pretergite (pt_2) of the metanotum actually belongs to the notum of the preceding segment and enters into the formation of the postnotum, or postscutellum of the mesothorax, when the latter is well developed. In the membranous area anterior to the pretergite are two small sclerites (v) which may possibly represent vestiges of the postscutellum. The pretergite is separated by an antecostal suture (acs) from the prescutum (psc_3) which follows it. The antecostal suture, as in the preceding mesothoracic segment, gives rise to a pair of inflections or lobes, termed the second phragma (ph_2), which serve for muscle attachment. Behind the prescutal suture ($pscs$) lies the large scutum (sc_3). A transverse membranous area (tm) extends across the scutum, and there is present internally at each end of the membranous area a lobe, or interphragma (iph_3), which serves for muscle attachment. The presence of both the transverse membrane and the interphragma would permit an arching and depressing action of the notal plate and this action may possibly play a role in the movement of the hind wings.

Behind this transverse membrane, medially, lies the scutellum (sl_3) which is flanked on either side by a depressed area, the parascutellum ($pscl_3$), which latter region is a part of the scutum. The posterior region of the notal plate folds under itself to give rise to the reduplication (rd). The reduplication is separated by a narrow membranous area from the postnotum, or postscutellum (psl_3), the posterior inflection of which gives rise to the third phragma (ph_3).

There are present in the metanotum a number of lateral projections as is the case in the mesonotum. There are the prealare (pa_3), the suralare (sur_3), the anterior notal wing process (anp_3) and the posterior notal wing process (pnp_3), whose functions are similar to those described for the mesothorax.

Pteralia (fig. 10).—The first axillary ($1ax_3$) articulates with the suralare (sur_3) and the anterior notal wing process (anp_3) mesally, and with the second axillary ($2ax_3$) laterally, while an anterior neck-like projection of the first axillary abuts against the base of the subcosta (Sc). The second axillary merges with the common base of the radius (R) and media (M) anteriorly, while posteriorly it articulates with the third axillary ($3ax_3$). The latter articulates with the fourth axillary ($4ax_3$), which probably represents a detached portion of the posterior notal wing process (pnp_3) and in this case the fourth axillary articulates with the posterior notal wing process.

Hind Wing (fig. 15).—The hind wing is the active flight organ of the katydid. It is divided by the vannal fold (vf), according to Snodgrass, into an anterior remigial region (rm) and a posterior vannal

region (*vn*). A number of secondary folds (*sf*) are present in the remigium. The tip of the hind wing, protruding from behind the tegmina, contains numerous venules which give it a tegmen-like texture. The vannal region is a thin membranous region, and it likewise contains a secondary fold (not shown) between each vannal vein which enables it to fold like a fan.

The veins of the hind wing are derived from a common V-shaped trunk, with its apex pointing toward the tip of the wing. The first vein arising from this trunk is the concave subcosta (*Sc*). This is followed by the convex radius (*R*) which branches twice near its distal extremity. The media (*M*) branches twice proximally; the anterior branch divides into a number of sub-branches, while the posterior branch of media divides into two sub-branches and the posterior of these two fuses with the first branch of the cubitus. The cubitus (*Cu*) arises from the apex of the V-shaped trunk and almost immediately divides into two branches. Behind the cubitus there is present the postcubitus (*Pcu*) of Snodgrass, which is the first anal vein of Comstock. Following it are the vannal veins (*V*) of Snodgrass or anal veins of other authors, which arise as convex veins but become concave halfway toward the margin of the wing.

Alaria (fig. 9).—There are two basalar sclerites (ba_3) present at the ventral base of the wing. The anterior of these is joined to the episternum (es_3) and indicates their probable origin as detached portions of the pleuron. Above the pleural wing process (pwp_3) is the intralare ($2ax_3$) or the ventral sclerotization of the second axillary, which serves as a pivoting structure for the wing. Posterior to the pleural wing process there is present an elongate subalare sclerite (sa_3). It is not definitely known whether the subalare is likewise of a pleural origin, as Snodgrass claims, or whether it arises as an independent sclerotization between the epimeron and the wing base.

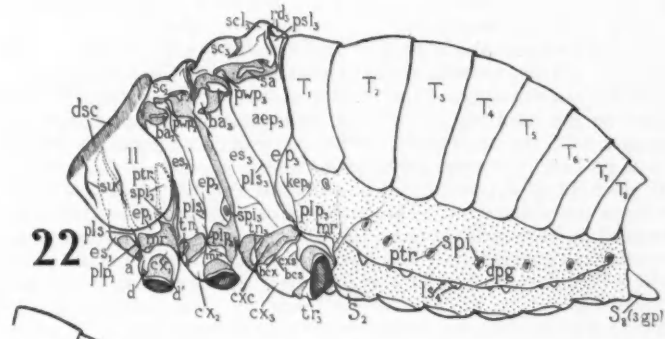
Metapleuron (fig. 22).—Along with the enlarged size of the metathorax we find that the metapleuron is larger than that of the mesopleuron. The episternum (es_3) is separated by the pleural suture (pls_3) from the epimeron (ep_3), which is divided into a broad upper anepimeron (aep_3) and a lower katepimeron (kep_3). A dorsal continuation of the episternum and epimeron along the pleural suture gives rise to the pleural wing process (pwp_3), while a ventral continuation of the same sclerites along the pleural suture forms the pleural leg process (plp_3). The second thoracic spiracle (spi_3) has migrated forward so that it is closely associated with the epimeron of the mesothoracic segment. Both precoxal and postcoxal bridges are lacking. The trochantin (tn_3) is similar to that of the preceding segment.

Hind Leg (figs. 19 and 22).—According to Snodgrass the proximal end of the coxa (cx_3) is girdled by a submarginal basicostal suture (*bcs*),

EXPLANATION OF PLATE IV

Abdominal structures of *Amblycorypha oblongifolia* (De Geer). Figure 22. Lateral view of thorax and abdomen. 23. Lateral view of male terminalia. 24. Posterior view of male terminalia showing phallus. 25. Ventral view of female terminalia, with subgenitalia plate pulled back. 26. Lateral view of ovipositor.

(For explanation of abbreviations see pp. 190–92.)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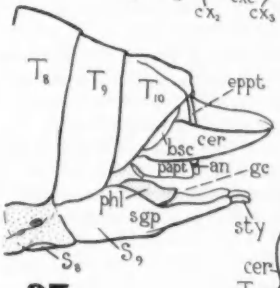
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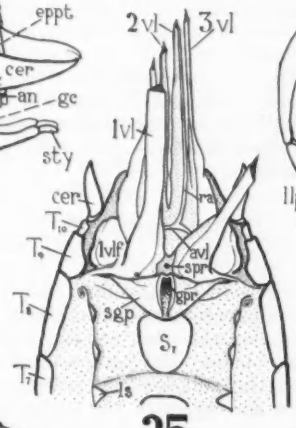
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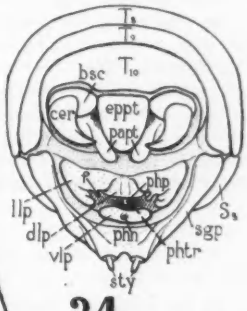
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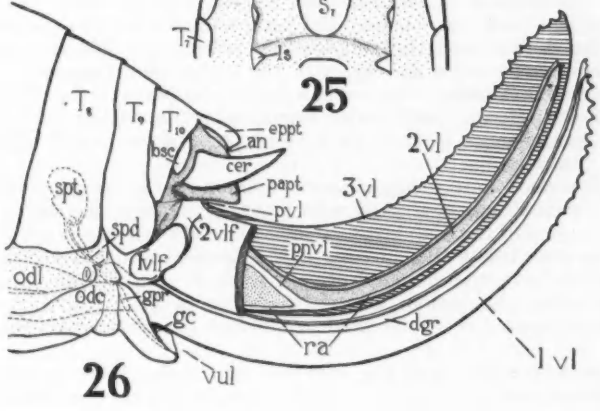
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which forms internally a ridge and sets off a marginal region, or basicoxite (*bcx*). The coxal suture (*cxs*) falls in line with the pleural suture, dividing the coxa into two parts. The coxal suture likewise divides the basicoxite into a prearticular portion and a postarticular portion. The postarticular portion is termed the meron (*mr*) and the suture which sets it off is a continuation of the basicostal suture. The meron is best developed in the hind leg. The coxa articulates with the pleural leg process and with the trochantin, while the articular membrane which surrounds its base is termed the coxal corium (*cxc*).

The trochanter (tr_3) is reduced to a narrow annualar sclerite, barely visible from the outer view. The femur (*fem*) is broadly developed at its proximal portion and contains the muscles used in jumping. The under surface is grooved and the inner edge is armed with spines. The tibia (*ti*) is similar to that of the preceding segment and is heavily armed with spines on all four of its margins. The tarsus (*ta*) and posttarsus (*psta*) has been described for the prothoracic leg.

Metasternum (fig. 13).—The basisternum (bs_3) is larger than that of the preceding segment and the posterior lobes are rounded, while an anterior portion has become sclerotized to form the presternum (ps_3). The furcasternum (*fs*) which follows contains a common furcal pit (fp_3) which gives rise to the furcal invagination. Internally this common furcal pit branches shortly, and each branch in turn gives off two sub-branches. According to Snodgrass no spinasternum is ever present in the metathoracic segment of insects (although it does occur in the metasternum of *Grylloblatta*).

ABDOMEN

Figures 22–26

In the following discussion of the abdomen the writer has attempted to follow Snodgrass as closely as possible in the terminology used to designate the regions of the abdomen and its various parts. Thus, considering the body as a whole, the back and sides above the limb bases is the dorsum and the undersurface between the limb bases is termed the venter, while the region of the limb bases themselves are termed the pleural areas. Each major segmental plate of the dorsum is termed the tergum; each major segmental plate of the venter is termed a sternum, and each major sclerotic plate of the pleural area is termed a pleuron.

If we likewise follow Snodgrass in the opinion that in the generalized segments of most insects the spiracles lie in the sides of the segments above the region of the limb bases, or in the lateral parts of the dorsum, then the groove below the spiracles is the dorso-pleural groove (*dpg*). The region above the dorso-pleural grooves is the dorsum of the abdomen, while the region beneath the dorso-pleural groove is the combined regions of the abdominal venter and the abdominal pleural areas.

The pregenital region of the abdomen, containing seven segments in the female and eight segments in the male, is discussed collectively under the heading of visceral segments, while the genital and post-

genital segments are considered separately under the discussion of the male and female terminalia.

VISCERAL SEGMENTS

A lateral view of the female abdomen is shown in fig. 22. It comprises by far the greatest volume of the insect body, reaching its greatest cross-section about the region of the third abdominal segment, then gradually tapering posteriorly. With little exception, the structure of the visceral segments is fairly uniform throughout.

Abdominal Terga (figs. 22–26).—The abdominal terga (T_1, T_2, etc.) are the major sclerotized plates of the dorsum of the abdomen. Each segmental area of the dorsum consists of a saddle-shaped tergal plate, followed by a wide, posterior membranous area which is folded beneath the posterior portion of the tergal plate, producing a telescoping effect. In the strictest sense of the word, however, each "segmental" tergum consists of a narrow, weakly sclerotized pretergal, or acrotergal area, demarked by an antecostal suture, which area actually belongs to the preceding segment. The antecostal suture forms an internal ridge, or antecosta, which serves for muscle attachment.

The pretergite of the first abdominal tergum is well developed and enters into the formation of the postnotum, or postscutellum (*psl*$_3$) of the metathoracic segment, as was mentioned in the discussion of the thorax, and the posterior inflection of the postscutellum forms the third phragma serving for muscle attachment. In each succeeding tergal plate, however, the pretergite is poorly defined and merges with the membranous area preceding it.

Spiracles (fig. 22).—There are eight pairs of abdominal spiracles (*spi*) which lie in the thickened membranous region of the dorsum above the dorso-pleural groove. Each spiracular opening lies in a small sclerotic area termed the peritreme (*ptr*).

Abdominal Sterna and Laterosternites (figs. 22, 23, 25).—Beneath the dorso-pleural grooves lie the combined regions of the abdominal venter and the abdominal pleural areas. Since no pleuro-ventral grooves are present, however, there is no way of distinguishing the pleural areas from the venter of the abdomen. The small triangular sclerites, immediately beneath the dorso-pleural groove, lie in the pleural region of the abdomen, but since there is no way of telling from this study alone whether these are derivatives of the primitive bases of abdominal appendages, secondary sclerotizations, or lateral subdivisions of the definitive pleurosterna, they are noncommitally termed laterosternites (*ls*). These laterosternites, lying in a thickened membranous region, are present on the first seven abdominal segments.

Lying medially in this pleurosternal region are the major sclerotic plates of the venter. Each of the first seven abdominal segments of the venter consists of an anterior sternal plate or sternum (S_1, S_2, etc.), followed posteriorly by a membranous area. The anterior margin of each sternal plate is inflected, forming an internal point for muscle attachment. The abdominal sterna gradually shift posteriorly in the female, so that the seventh sternum (S_7) appears to lie beneath the eighth tergum.

FEMALE TERMINALIA

Figures 25 and 26

The eighth and ninth segments of the female abdomen are adapted by structural and appendicular modifications to perform the genital functions, and are referred to as the genital segments, and are followed by the tenth and eleventh segments which are the postgenital segments. The genital and postgenital segments together with their appendages comprise the terminalia.

The Eighth Segment.—The eighth tergum (T_8) differs little from the visceral terga preceding it. The pleural area, however, contains a sclerotized portion which forms the first valvifer (*1 vlf*). The anterior portion of the first valvifer, which has shifted ventrally, bears the long, curved, blade-like structures which are the first, or ventral valvulae (*1 vl*) of the ovipositor. (The ovipositor of Orthoptera consists of three pairs of valvulae, a first, second and third pair, although in Acrididae and Gryllidae the second pair may be reduced or rudimentary. In other insects which bear an ovipositor, such as Thysanura, Hemiptera and Hymenoptera, there are only two pairs of valvulae and these are the first and second pairs.) The upper, outer margin of the first valvula contains a dorsal groove (*dgr*) which interlocks with the ventral edge of the third, or dorsal valvula (*3 vl*), while the ventral margin of the first valvula is strongly toothed apically. The posterior, or upper portion of the first valvifer bulges and overlaps a basal portion of the dorsal valvula.

The eighth sternum (S_8) forms a triangular, subgenital plate (*sgp*) which underlies the bases of the first valvulae. Between the ventral bases of the first valvulae and the dorsal surface of the subgenital plate, there is formed a genital chamber (*gc*).

Fig. 25 shows a ventral view of the female terminalia with the subgenital plate pulled back anteriorly, exposing the genital chamber. The genital chamber is an external pouch, or pocket, formed between the ventral bases of the first valvulae and the dorsal surface of the eighth sternum. The median gonopore (*gpr*), which is the true external genital opening, is located anteriorly on the floor of the genital chamber, which floor forms the dorsal surface of the subgenital plate. The posterior opening of the genital chamber, which receives the male spermatophore, is termed the vulva (*vul*). The gonopore is the opening of the median oviduct (*odc*) (shown by broken lines in fig. 26) into which the paired lateral oviducts (*odl*) discharge. The membranous lips of the gonopore continue posteriorly along the dorsal surface of the subgenital plate, and form a membranous subchamber, within the genital chamber. Located on the roof of the genital chamber, between the bases of the ventral valvulae, is the minute spermathecal aperture (*spr*), which leads through a narrow spermathecal duct (*spd*) into the sac-like spermatheca (*spt*) in which the female stores the sperm after copulation.

It should be noted that the eighth sternum, or subgenital plate, and the first valvifers have shifted posteriorly, and appear to be more closely associated with the ninth tergum than with the eighth tergum to which they actually belong.

The Ninth Segment.—The ninth tergum (T_9) is somewhat narrower than the eighth tergum, and its antecostal ridge is strongly developed, particularly along its lateral portions, serving for the attachment of the muscles associated with the ovipositor.

The pleural area of the ninth segment is represented by the reduced second valvifers (*2 vlf*). The anterior portion of the second valvifer gives rise to the second, or inner valvulae (*2 vl*) of the ovipositor, while the posterior portion of the second valvifers bears the third, or dorsal valvulae (*3 vl*). This relationship of the inner and dorsal valvulae to the second valvifer is not altogether evident outwardly, since the aides of the dorsal valvulae have grown down about the inner valvulae and the latter have been displaced posteriorly. The relationship of the parts of the ovipositor is further obscured in the adult by the fact that the ventral bases of the inner valvulae have fused with the bases of the dorsal valvulae (fig. 26) and the second valvifers have been displaced dorsally by the first valvifers. If careful study is given to the development of the ovipositor in this family, however, the true relationship of the parts of the ovipositor to one another becomes clear, as has been shown by Walker, Snodgrass and others.

The bases of the inner valvulae are fused with one another, and are in turn fused with the bases of the dorsal valvulae. The fused bases are strengthened and united by a narrow transverse sclerotic bar, or anterior intervalvula (*avl*) (fig. 25). Laterally this bar unites with the dorsal valvulae, and further sends two sclerotic continuations posteriorly along the ventral edges of the inner valvulae, which are termed the rami (*ra*). Each ramus sends a sclerotic continuation or pons valvulorum (*pnvl*) anteriorly along the outside of the inner valvulae which unites dorsally and meet a narrow transverse, termed the posterior intervalvula (*pvl*), at the dorsal base of the inner valvulae. Where the united pons valvulorum meets the posterior intervalvula, there is a pit-like invagination which gives rise to an internal apodeme which serves for muscle attachment. The lateral extremities of the posterior intervalvula unite with the dorsal valvulae.

The dorsal valvulae which enclose the inner valvulae are the broadest blades of the ovipositor. The upper edges are sharply toothed posteriorly, while the ventral edges are smooth and lock with the dorsal grooves of the ventral valvulae.

Briefly the passage of the egg from the female may be summarized as follows. The egg passes down the lateral oviduct (*odl*) into the median oviduct (*odc*) and out through the gonopore (*gpr*). As the egg passes out through the gonopore, into the subgenital chamber, it is fertilized by one of the sperm which is pumped out through the spermathecal aperture (*spr*). The lips of the gonopore which extend posteriorly apparently guide the egg between the ventral valves, down which it passes before being inserted into the ground. It should be noted that the deposition of eggs into the ground is unique among the Phaneropterinae, the edges of leaves and twigs being the usual depository. The following account of Hancock is taken from Blatchley (1920, p. 479):

"When ready to oviposit . . . the female curves her abdomen, which is now distended with eggs, forward underneath her body and at the same time seizes the end of the large ovipositor in her mandibles.

In this way she directs its point to the desired point in the ground. Then she forces or drills a hole in the earth for the reception of each egg or cluster of eggs."

The Tenth Segment.—The tenth tergum (T_{10}) is greatly reduced and narrowed. Medio-dorsally it unites with the eleventh tergum, or epiproct, although a constriction remains at each side to demark its former limits. The antecostal ridge is well developed. The tenth segment lacks appendages and the venter is entirely membranous and reduced.

The Eleventh Segment.—The eleventh segment bears the anus (*an*) posteriorly. Its tergum forms the short, broad, supra-anal plate, or epiproct (*eppt*), while the ventro-lateral parts of the segment form two membranous lobes, or paraprocts (*papt*), on each side of the anus.

Below the epiproct, and almost immediately behind the tenth tergum, is the single-segmented cercus (*cer*), which, though it appears to be borne by the tenth segment, is a recognized appendage of the eleventh segment. At the base of the cercus is a small sclerotized plate, or basi-cercus (*bsc*).

THE MALE TERMINALIA

Figures 23 and 24

Contrasted with the female, the male has only a single genital segment, or gonosomite, which is the ninth segment. The eighth segment thus remains a pregenital, or visceral segment and is similar to those segments as described in the female.

The Ninth Segment.—Apart from a slight difference in size, the ninth tergum (T_9) differs but little from the preceding visceral segments.

The ninth sternum (S_9) enters into the formation of the male subgenital plate (*sgp*), which bears a pair of styli (*sty*) posteriorly (fig. 23). It is apparent from the presence of the styli, however, that the subgenital plate consists of the gonopod bases, which have shifted from their original pleural position and fused with the definitive sternal plate. The dorsal surface of the subgenital plate is concave and forms a genital chamber (*gc*) which contains the phallus (*phl*).

The phallus arises medially on the intrasegmental membrane of the ninth segment which has invaginated inward in the formation of the genital chamber. Fig. 24 shows a dorso-posterior view of the phallus. In its ordinary retracted state the phallus appears to be a short, broad, fleshy lobe within the genital chamber. Closer examination, however, reveals the phallus to consist of a dorsal lobe (*dlp*), a pair of large lateral lobes (*llp*), and a ventral lobe (*vlp*), which fold together tightly about the posterior opening of the phallus, or phallotreme (*phtr*). The ventral surface of the dorsal lobe bears a phallic papilla (*php*) posteriorly, which fits into a phallic notch (*phn*) on the ventral lobe, enabling the lobes to remain tightly locked together while the phallus is not in use. The phallotreme opens into the endophallic cavity which, in turn, opens anteriorly into the ejaculatory duct through the gonopore. The armature, or modified lobes, usually present on the dorsal surface of the dorsal lobe in the phallic organs of other Tettigoniids, is lacking.

The "flat, tonguelike fold that divides the endophallic cavity into a dorsal and ventral compartment," mentioned by Snodgrass (1937, p. 67), is probably the fold (*f*) borne by the lateral lobe, which serves to lock the lateral lobes with the lateral edges of the dorsal lobe when the phallus is retracted. The writer was able to view the phallus of a specimen containing a spermatophore, which when removed left the phallus in a protracted state and there was apparently no functional division of the endophallic cavity into two compartments. It should be noted that the phallus is used to form the spermatophore, and is not an intromittent organ.

The Tenth Segment.—The tenth tergum (T_{10}) suffers a reduction in size. Dorsally it contains a triangular median depression. The pleurosternal area of the tenth segment is greatly reduced and is represented by the membranous region above the phallus.

The Eleventh Segment.—The eleventh tergum forms the epiproct (*eppt*) above the anal opening. In the male the epiproct is bent sharply downward. The anus is flanked on each side and somewhat ventrally by the paraproct (*papt*). The eleventh segment bears the cerci (*cer*), which in the male are curved inward and may possibly have a clasping function. The sclerotic area at the base of the cercus is the basicercus(*bsc*).

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EXPLANATION OF ABBREVIATIONS

a.....pleural leg articulation.
aar....antennal articulation area
acs....antecostal suture
aep....anepimeron
af.....antennifer
an.....anus
anp....anterior notal wing process
ao.....auditory organ
ap.....antennal pivoting process
asc....antennal sclerite
aso....antennal socket
at.....anterior tentorial arm
atp....anterior tentorial pit
avl.....anterior intervalvula
1 ax....1st axillary
2 ax....2nd axillary
3 ax....3rd axillary
4 ax....4th axillary
axc....axillary cord

b.....trochantinal articulation of coxa
ba.....basalare
bc.....basicardo
bcs....basicostal suture
bcx....basicoxite
bg.....basigalea
bl.....basilingua
bls....basilingual sclerites
br.....brustia, or brush of mandible
bs.....basisternum
bsc....ball of scape (Plate I); basicercus (Plate IV)
bta....basitarsus

c.....cardo
cb.....cibarium
cds....cardinal suture
cer....cercus
clp....clypeus
cm.....cervical membrane
co.....condyle
cp.....internal cardinal process
cph....cephaliger
cpt....corporotentorium

ct.....cardinal tendon
Cu.....Cubitus, or cubital vein
cv.....cervix
cx.....coxa
cxc....coxal corium
cxs....coxal suture
cxsp...coxal spine

d,d'....coxo-trochanter articulations
dc.....disticardo
dg.....distigalea
dgr....dorsal, interlocking groove of ovipositor
dl.....distilingua
dlp....dorsal lobe of phallus
dls.....distilingual sclerite
dpg....dorso-pleural groove
dsc....disc of pronotum

e.....compound eye
ec.....epicardo
eg.....endognath
ep.....epimeron
epg....epignath
eppt...epiproct
es.....episternum
et.....extensor tendon

f.....file of rasping vein (Plate II); fold (Plate IV)
fem....femur
fm.....food meatus
fp.....furcal pit
fr.....frons
fs.....furcasternum
fst.....fastigium
ft.....flexor tendon

g.....ginglymus
ga.....galea
gc.....genital chamber
ge.....gena
gn.....gnathite
gpr....gonopore

in.....incisor region
iph....interphragma

kep....katepimeron

la.....lacinia
lb.....labium
lbs.....labial suture
lc.....lateral cervical sclerite
ld.....lacinio-dentes
lf.....lacinial fringe
ll.....lateral lobe of pronotum
llp.....lateral lobe of phallus
lp.....labial palpus
lr.....labrum
ls.....laterosternite
lst.....labial stipites

M.....Media, or medial vein
m.....mola
ma.....muscle attachment
map...midappendix
me.....auditory membrane
mn....mentum
mp....maxillary palpus
mr.....meron
mth....mouth

nf.....neuroforamen

oc.....occipital condyle
ocf.....occipital foramen
odc....median oviduct, or oviduct communis
odl.....lateral oviduct, or oviduct lateralis

pa.....prealare
pap....postoccipital process
papt...paraproct
pcu....postcubitus
pcx....precoxale
pdc....pedicel
pga....postgenal acetabulum, or postgenotheca
pge....postgena
pgs....postgenal suture
ph.....phragma
phl....phallus
phn....phallic notch
php....phallic papilla
phtr...phallotreme
phy....pharynx
plf.....palpifer
plg....palpiger
plp....pleural leg process
pls....pleural suture
pn.....pronotum
pnp....posterior notal wing process
pnvl...pons valvulorum
poc....postocciput
pocx...postcoxale
poe....postepipharynx
pos....postoccipital suture
pp.....postgenal process
ppd....postpedicel
prc....preoral cavity
pre....preepipharynx
ps.....presternum
psc....prescutum
pscl....parascutellum
pscs...prescutal suture
psl....postscutellum, or postnotum
pst....parastipes
psta...posttarsus
psts....parastipital suture
pt.....posterior tentorial arm (Plate I); pretergite (Plate II)
ptp....posterior tentorial pit
ptr....peritreme of spiracle
pu.....pulvillus

pvl....posterior intervalvula
pwp...pleural wing process

R.....Radius, or radial vein
r.....rasp
ra.....ramus
rc.....resonating chamber
rd.....reduplication
rm.....remigium
rv.....rasping vein

S.....sternum
s.....secondary suture
sa.....subalare sclerite
Sc.....Subcosta, or subcostal vein
sc.....scutum
scl.....scutellum
scp....scape of antenna
sf.....secondary wing fold
sge....subgena
sgp....subgenital plate
sgs....subgenal suture
sl.....sternellum
sld.....salivary duct
slv.....salivarium
sm.....salivary meatus
smn...submentum
sp.....spinal pit
spd....spermathecal duct
spi....spiracle
spr....spermathecal aperture
spt....spermatheca
st.....stipes
sty.....stylus
su.....sulci
sur....suralare

T.....tergum
t.....tendon
ta.....tarsus
te.....temporal region
tf.....tentorial furca, or pit
ti.....tibia
tm.....transverse notal membrane
tn.....trochantin
to.....tormae
tr.....trochanter
ts.....temporal suture
tsm....tarsomere
tym....tympanum

unf....unguifer
ung....ungue, or claw
utr....unguitractor

v.....vestigial sclerites (of postnotum?)
V.....vannal vein
vf.....vannal fold
vl.....valvula
vlf.....valvifer
vlp....ventral lobe of phallus
vn.....vannal region, or vannus
vs.....V-shaped, surlingual sclerite
vul....vulva
vx.....vertex

LYCAENIDAE OF THE ANTILLES (LEPIDOPTERA, RHOPALOCERA), by WILLIAM P. COMSTOCK and E. IRVING HUNTINGTON. Annals of the New York Academy of Sciences, Vol. XLV, Art. 2, pp. 49–130; 1 plate, 1943. Published by the Academy.

This revision of a difficult group of butterflies from a complex faunal area differs refreshingly from many older works of its kind. One of its features is the early elimination of twenty names as unrecognized or extralimital, with discussion of past treatment where it has been important. Any taxonomist who has struggled with species named in older works and since inadequately identified will appreciate the wisdom and courage of this course, so strongly contrary to the burning taxonomic urge to sweep the field and pigeonhole every name.

From this point the bulk of the revision consists of the authors' systematic account. The reviewer is always unwilling to criticize specific treatment unless he has well supported opinions in the same group, which is not true here. The treatment appears to be careful, thorough and judicious in its evaluation of the available material. The prevalence of trinomials is a feature against which the reviewer continues to protest. Such subdivisions are a matter of opinion. They can be useful, but God forbid that we should go to the extremes that have been attained in the European fauna.

The final section is a brief but very interesting analysis of the interrelations of the insular and certain continental forms. And here, in conclusion, the writers express a laudable reluctance to pursue some fascinating zoogeographical temptations beyond the legitimate interpretation of the available evidence.

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DOUTTIA, A NEW GENUS OF NEW HEBRIDEAN CURCULIONIDAE

(Coleoptera: Cryptorhynchinae)

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Among some insects collected by Lt. R. L. Doutt, United States Air Force, while on duty in the southwest Pacific was a pair of weevils which represent a new genus and species. In spite of the exigencies of battle front conditions, Lt. Doutt made several collections of insects during spare moments, but all but one lot of specimens were lost. It is a pleasure to dedicate the newly discovered genus to Lt. Doutt in appreciation of his efforts to gather specimens of scientific value in spite of his preoccupation.

Douttia, new genus

Body *Trigonopterus*-like in form; mostly bare above, but with patches of squamae.

Head with crown exposed from above; interocular area narrowing dorsad, narrowest part narrower than base of rostrum; eyes large, coarsely faceted, subcontinuous in outline with head. Rostrum approximately as long as pronotum, arcuate, depressed, comparatively slender; mandibles bidentate; scrobes lateral and concealed from above; antennae inserted behind middle in both sexes. Antennae with scape reaching base of rostrum, shorter than funiculus excluding club; funiculus 7-segmented, first two segments elongate and subequal, segments 3 to 7 successively shorter and more transverse; club ovate, about one half as long as funiculus, shorter than scape.

Prothorax subconical, transverse; base subtruncate; postocular lobes obtuse. Scutellum minute. Elytra subcontinuous in lateral outline with prothorax; humeri not prominent; base sinuate; ten striae; intervals broad. Wings reduced or aborted.

Legs with femora not or but slightly clavate, partly, shallowly and obscurely grooved beneath, not toothed, extending to or slightly beyond apex of elytra; tibiae angulate at base, otherwise almost straight, not multicarinate, terminal uncus well developed, but without a tooth at inner apical angle; tarsi with segment 1 elongate, longer than 2, 2 about as long as 3, 3 very broad, deeply bilobed, 4 projecting well beyond apex of 3; claws well developed, stout, divaricate.

Sternum with prosternum much longer in front of coxae than length of a fore coxa; pectoral canal deep, bare, terminating between mesocoxae; mesosternal receptacle broadly open behind, side walls high and strongly developed, hind wall absent; metasternum much shorter at its narrowest point between mid and hind coxae than the

longitudinal chord of a mesocoxa; metasternal episterna narrow; metacoxae almost reaching elytra.

Abdomen with ventrite 1 longer than 2, longer than length of metasternum along median line, intercoxal process broadly arcuate or broadly sub-Λ-shaped, without carinae or striae, on a lower plane than ventrite 2; suture between ventrites 1 and 2 coarse and distinct throughout; ventrite 2 longer than 3 or longer than 3 plus 4 which are subequal in length and together are shorter than 5.

Genotype: ***Douttia bicolor***, new species.

Without detailed examination, the genotype appears to belong to *Trigonopterus* Fauvel. It has the same general form, color pattern, and facies of a number of species of that large and widespread genus. However, the open mesosternal receptacle alone immediately will separate the two genera. Moreover, in addition to the character differences of the mesosternal receptacle, there are many other morphological features of *Douttia* which are quite distinct from those of *Trigonopterus*. In typical *Trigonopterus* neither the scutellum nor the metepisterna are visible, the femora are deeply and conspicuously sulcate beneath, the tibiae are usually conspicuously multicarinate, the tarsal claws are minute and the rostrum is much stouter than in *Douttia*.

In Lea's key to the Australian genera allied to *Trigonopterus* (*Idotasia*) (Trans. Royal Soc. South Australia, 52 : 154, 1928), *Douttia* will run to *Leucomelacis* Lea, 1928. *Leucomelacis* has the sutures of the second to fourth ventrites "drawn backwards at the sides," an aberrant character which alone will serve to separate the two genera.

It is to be anticipated that a number of new species of this genus will be discovered when the Melanesian islands are adequately explored.

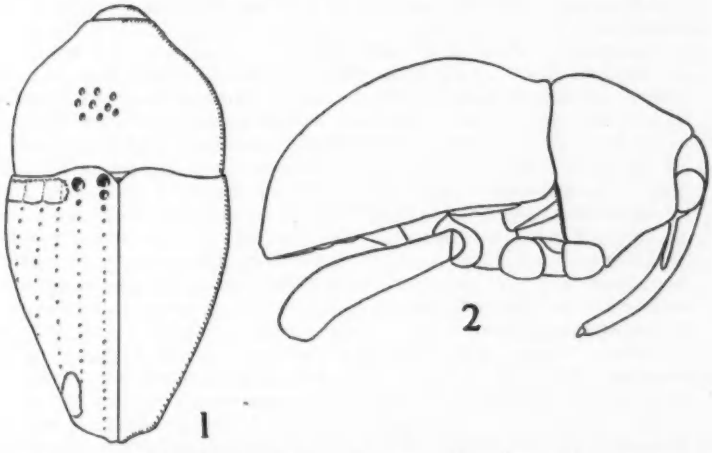
Douttia bicolor, new species

Figures 1 and 2

Color.—Derm dark wine-red to black, variable, dorsum shiny; scales on head mostly brown, but with a conspicuous white patch along median line which is about as broad as interocular area at top of eyes but which narrows toward pronotum; pronotum without squamose patches; each elytron with a conspicuous basal band of dense, snow-white scales extending across intervals 4 to 9 inclusive with a few scales extending on to outer edge of interval 3, greatest cephalic-caudal length of the band almost as great as breadth of intervals 4 plus 5, and each elytron with a conspicuous elongate patch of similar scales subapically situated on declivity, mostly on interval 3 but occupying the shallow concavity between terminations of striae 2 to 8, this vitta separated by about one half its length from apex of elytron, about as long as distance across first three or four striae at basal margin of elytron, and about three times as long as its breadth; legs with femora conspicuously clothed along dorsal edge for one third to one half distal length with dense, ovate, snow-white squamae, elsewhere with less conspicuous, more scattered brown scales or with additional white squamae along lower edges, especially toward base; tibiae with brown and white scales, white scales predominating internally and usually apically on outer edge; scales and setae of ventral surfaces white.

Head.—Crown evenly convex, but slightly flattened or depressed at position of the vague median fovea; interocular area gradually narrowed from base of rostrum to tops of eyes, and there more than two-thirds as broad as base of rostrum; crown densely clothed with ovate, appressed scales which conceal the shallowly punctate, coarsely reticulate derm, all scales directed forward excepting the anterior ones in the white vitta which are directed backward; interocular area sparsely squamose, with most of the scales along sides.

Rostrum.—The chord measured from lower cephalic corner to lower apex as long as a fore tibia including uncus in male, one sixth longer than a tibia in female; gradually and slightly narrowed from base to insertion of antennae, thence gradually and slightly widened



FIGURES 1 and 2. *Douttia bicolor*, new genus and species, outline diagrams of dorsal (fig. 1) and lateral (fig. 2) aspects to show principal features (female).

to apex, apex very little broader than breadth at antennae; antennal insertion at basal two-fifths in male and at basal one-third in female; with a sulcus and carina above each scrobe, but otherwise not sulcate nor carinate; male with post antennal area comparatively coarsely punctate, punctures longitudinally confluent or subconfluent, area beyond antennae densely set with smaller punctures; female with postantennal area less coarsely punctured, and with minute punctures beyond antennae.

Antennae.—Scape clavate, sinuous, sparsely setose, as long as first four funicular segments or slightly longer, at its broadest point about equal in breadth to first funicular segment; funiculus with first two segments subequal in length, but 1 about one-third broader than 2, 2 slightly longer than 3 plus 4, segments 3 to 7 successively broader, 7 about one-third broader than long and approximately as broad as 1; club ovoid, not quite as long as five preceding segments combined.

Prothorax.—Proportions in male allotype 34 units wide and 26 long and in female holotype 36 units wide and 27 long; broadest behind middle, broadly rounded on sides from base to near apex and there distinctly constricted, the constriction hardly interrupting longitudinal dorsal outline; longitudinal dorsal contour most strongly convex at base, and there rising distinctly above base of elytra; disk bearing medium-sized, round or oval punctures, well separated caudad, but more numerous and more closely placed cephalad, and larger, coarser and closer on pleura, becoming longitudinally confluent or subconfluent along pectoral canal and on postocular lobes, each puncture bearing a short inconspicuous seta; scales absent; hind margin at most shallowly and indistinctly sinuous, slightly overlapped by bases of elytra, coarsely and closely punctured, with the coarsely punctate area broadest and most coarsely sculptured in front of scutellum.

Scutellum.—Punctiform, inconspicuous.

Elytra.—Base distinctly sinuous, not broader than base of prothorax, broadly arcuate on sides to the broadly rounded, sub-truncate apices, broadest a short distance behind humeri and there about equal in breadth to greatest breadth of pronotum, about seven-tenths as broad as long and about twice as long as length of pronotum; longitudinal dorsal contour conspicuously discontinuous with that of pronotum, depressed at base for about one-half breadth of the squamose fascia, then rising to reach its highest point before middle and there on a higher plane than pronotum, thence continuing in a broad curve to apex; squamae in basal and subapical patches dense, imbricated; scaling in basal patch not continued to absolute base and striae appearing as narrow lines through scaling; striae 9 and 10 impressed to apex, but other striae obsolete or nearly so excepting at base and apex and marked only by inconspicuous or small punctures smaller and shallower than those on pronotum on disk, but each marked by large, coarse, deep punctures at base, the large punctures successively more numerous in outer striae, elytral disks appearing smooth, without any strial and interval irregularities; setae hardly discernible except at apex and short there; interval 1 slightly elevated and stria 1 depressed at apex.

Legs.—Femora closely punctate, not dentate, but with anterior edge of fore pair rather coarsely sculptured and somewhat minutely irregular and with or without a minute denticle; anterior femora with long, white, hair-like setae on ventral edge in male only; greatest width of hind femora divided into length equals about 3.05; tibiae arched at base, thence almost straight, uncus arising from outer apical angle and well developed, without any carinae, lower edge with more numerous longer setae; dorsal parts of tarsi clothed with white setae, under surfaces densely setose; hind tarsus with segment 1 as long as 2 plus 3, 2 as long as and one-half as broad as 3, 3 deeply bilobed, each lobe about as broad as 2, segment 4 arising near base of 3 and as long as breadth of 3, claws about as long as basal breadth of segment 3.

Sternum.—Fore margin of prosternum deeply concave at the deep pectoral canal, side margins of canal in front of coxae about

one-fourth longer than length of a fore coxal cavity, distance between a coxa and hind margin of prosternum less than one-third length of a fore coxa, intercoxal distance one-third length of a fore coxa; fore coxae with a patch of white, erect or suberect setae and squamiform setae at distal, inner, hind corner; mesosternal receptacle with side walls sloping upward and backward to level of metasternum, fore edges touching fore coxae and there on about same level as squamose patch on fore coxae (this condition is evident only when the prothorax is drawn against the after body in its natural position of rest), lower edges densely clothed with long, bristly, erect, coarse, hair-like setae in male and with erect mostly squamiform setae and with a few fine scattered setae in female; mesocoxae with large, conspicuous, ovate squamae; metasternum deeply concave in both sexes, hind margin deeply concave, the length along median line only about one-half length of ventrite 1, clothed with ovate squamae, which are more numerous toward sides and with slender, very narrowly lanceolate, slanting setae in female, but densely clothed with long, shaggy white hair in male and with ovate squamae on sides in both sexes; side pieces of meso- and metasternum squamose.

Abdomen.—Of female: ventrite 1 about as long as 2 plus 3, convex, with large closely placed punctures bearing fine reclinate setae and with a few ovate squamae near coxae and along hind margin; ventrite 2 shiny, slightly longer than 3 plus 4, slanting conspicuously downward and forward, with small punctures bearing fine setae and with a single or partially double row of large ovate squamae along posterior margin; ventrites 3 and 4 subequal in length and together about as long as 5, arrangement of vestiture similar to that on 2, punctures inconspicuous; ventrite 5 closely punctate, with reclinate setae and a few squamae. Abdomen of male: ventrite 1 almost as long as 2 plus 3 plus 4, with the disk deeply and broadly concave, the concave area densely clothed with very long, shaggy, white hair, but the sides squamose; ventrite 2 about as long as 3 plus 4, coarsely sculptured, coarsely alutaceus, with scattered setae and with both fore and hind margins squamose; ventrites 3 and 4 with about their posterior halves conspicuously squamose; ventrite 5 densely punctate, setose on disk and squamose at base and on sides.

Length: 3.5–3.75 mm. (excluding head); breadth: 1.75–1.9 mm.

Types.—Holotype female and allotype male collected by Lt. R. L. Doutt on Espiritu Santo Island, New Hebrides, September 19, 1942, and deposited in Bishop Museum, Honolulu, T. H.

I have designated the female as holotype because the male has lost the left antenna and the left postocular lobe is deformed (it is notched instead of being convex). The male is almost entirely black, whereas the female has the prothorax and elytra largely dark wine-red. The contrast between the snow-white squamose patches and the black or reddish background forms a pleasing color combination.

THE RELATIONSHIP OF DASYMUTILLA PERMISTA MICKEL TO DASYMUTILLA QUADRIGUTTATA (SAY) AND BEHAVIOR NOTES ON THE SPECIES

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A problem frequently encountered in the family Mutillidae is the correct correlation of males and females of a species. The great dissimilarity of the sexes of members of this family makes it frequently impossible to connect males and females by study of preserved specimens alone. Biological observations are necessary to establish conspecific identity of males and females. Three types of observations appear to best show the correlation of males and females: (a) copulating pairs are almost certainly of the same species; (b) males and females reared from the same host are probably conspecific; (c) numerous identical males and identical females in the same area simultaneously may be suspected to be of one species. The evidence which follows proves through all three methods that *Dasymutilla permista* Mickel is the male, and thus a synonym, of *Dasymutilla quadriguttata* (Say).

In his study of the genus *Dasymutilla* Ashmead, Mickel[2] discussed the possible relationship of *D. quadriguttata* (Say), known in the female sex only, and *D. permista* Mickel, known only from males. He pointed out that since Hayes had reared both species from cocoons of *Elis quinquecincta* Fabricius the two might possibly be conspecific, but this seemed improbable because *permista* occurs not only in the same area as *quadriguttata* but also much farther eastward. It is possible that *D. interrupta* Banks is a geographic race of female *D. quadriguttata*, replacing the latter east of Minnesota, Illinois, and Mississippi. This problem needs study.

On July 2, 1943, the writer was surprised to find great numbers of male mutillids coursing back and forth over a large grass lawn situated among heavily wooded hills on the eastern bank of the Mississippi River. No mutillids had been seen there previously, although the writer had crossed the place while searching for insects on each of the several preceding days. About thirty-five were caught in twenty minutes, as many as three being taken in single sweeps of the net. With a sufficient amount of collection material, the writer then began watching the actions of the handsome wasps.

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[1]Thanks are due Dr. C. E. Mickel for verifying the identification of the pair seen to mate and the other males and females taken at the same place. The pair seen in coitus and additional males and a female have been placed in Dr. Mickel's extensive collection of Mutillidae.

Dr. H. K. Townes kindly verified the identification of the *Myzine quinquecincta* (Fabricius).

[2]Mickel, Clarence E. 1928. Biological and taxonomic investigations on the mutilid wasps. U. S. Nat. Mus. Bull. 143.

Each of the several hundred males visible was slowly and irregularly flying over the lawn less than six inches above the recently-cut grass. Every few minutes the wasps would alight and begin crawling through the grass, taking wing again in about thirty seconds. Several individuals were followed for five to ten minutes each, and on no occasion did a male find the object of his search (presumably a female). On July 5 a female was followed for twenty-five minutes, during which period it moved steadily through the grass. It was exposed to full view more than half the time, but no males discovered it during the period of observation. Several males flew within three inches of the moving and conspicuously-marked female, and others actually crawled through the grass within four inches of her, without discovering her. Some showed apparent excitement on crossing a spot where the female had just passed, but their searching was aimless and fruitless.

On July 2, after no copulating pairs could be found, the writer placed a male (*permista*) in a glass bottle with a female (*quadriguttata*). The male attempted to escape for about a minute, and then discovered the female. He immediately lit on her back and went into coitus with her. After approximately three seconds of copulation, he flew up, and evidenced no further interest in her. This behavior definitely indicates that *D. permista* and *D. quadriguttata* are the same species.

In the observations carried on between July 2 and 5, only a few lone individuals of these mutillids were seen beyond the edges of the lawn. In addition, no other species of mutillids were observed on the lawn during that period. Several hundred males were observed, and industrious searching yielded four females. The difficulty in finding the latter was because their winglessness confined them to the ground, where the grass easily concealed them.

It was of interest to note that both males and females made a high-pitched squeaking noise when captured. Mickel has shown that this sound is produced by rubbing the third abdominal tergite against the underside of the second tergite. In all cases observed by the writer this sound appeared to be made in protest rather than as a signal, as none of the free individuals nearby seemed attracted to the captive sound-producing wasps. Free males and free females were never heard to make these sounds. No difference was perceived between the noises made by males and by females.

An effort was made to find indications of the host or hosts of *D. quadriguttata*. Only one other wasp was present on the lawn in conspicuous numbers, *Myzine* (*Elis*) *quinquecincta* (Fabricius). These wasps were nearly as numerous as the mutillids, and pairs of *M. quinquecincta* were twice seen to copulate. In the light of Hayes' findings and the above observations, it seems safe to suppose that *M. quinquecincta* is the host of *D. quadriguttata* on the campus of Principia College near Elsah, Jersey County, Illinois, where these studies were made. The writer's entrance into the Army necessitated discontinuance of these investigations.

SUMMARY

A male *Dasymutilla permista* Mickel was seen to mate with a female *Dasymutilla quadriguttata* (Say). These therefore represent one species.

Quadriguttata, being the older name, must stand, and *permista* falls under it as a synonym.

Certain observations of the habits of this species are set forth: (1) Hundreds of males were seen flying over the limited area covered by a large, close-cut lawn. Their interest seemed to be in finding females. (2) These males seemed remarkably unsuccessful in discovering females, even when passing within a few inches of an active and conspicuous female. (3) Coitus lasts only a few seconds with this species. (4) Both sexes make a high-pitched squeaking when caught. This sound appears to be a manifestation of fear or annoyance, and not a signal; free wasps showed no response to loudly squeaking captives. (5) The great abundance of *Myzine quinquecincta* (Fabricius) on the lawn with the mutillids, coupled with Hayes' rearing of *D. quadriguttata* from *M. quinquecincta* cocoons, leads the writer to believe that the tiphiid is the host of the mutillid where the above investigations were made.

THE ORGANIZATION OF PERMANENT NATION-WIDE ANTI-AEDES AEGYPTI MEASURES IN BRAZIL, by FRED L. SOPER, D. BRUCE WILSON, SERVULO LIMA, and WALDEMAR SA ANTUNES. 137 pages, 27 figures. The Rockefeller Foundation, 49 W. 49th Street, New York 20.

The history of yellow fever is not a closed chapter. Frequently we are guilty of thinking too often in terms of the past and failing to recognize what contemporary students are doing. Knowledge of yellow fever has increased greatly since 1925. An outstanding discovery, in recent years, was that the disease occurs as one of jungle animals, independent of man and *Aedes aegypti*, in many South American countries.

Outbreaks of yellow fever in cities is believed due largely to invasion by the virus from the jungle. When cities have *Aedes aegypti* there is opportunity for a serious epidemic following introduction of the virus.

Anti-*aegypti* campaigns in Brazil aimed at the reduction of the species in cities have been discarded for a strategy of eradication of this mosquito from the entire country. This daring program, fostered in large part by the International Health Division of the Rockefeller Foundation, is now under the control and at the expense of the Brazilian government.

Briefly stated, the program consists of an initial clean-up campaign followed by elimination of those few places responsible for maintaining the species, and the maintenance of an organization to prevent reinfestation or to cope with the problem in case reinfestation occurs.

The methods of combat used by the Yellow Fever Service are thoroughly described but since they are well known, at least in their major aspects, to all entomologists acquainted with the practice and literature of mosquito control, they will not be discussed here. The organization and administration of the program are elaborately described and form the major portion of the book. The success of the Brazilian project is largely due to proper use of an elaborate system of maps and reports which are filled out by every worker. Also important in success is the expenditure of approximately 25 per cent of the labor budget in checking all work done.

This book is nicely printed and bound and it has an index. It has a limited distribution free of charge to doctors and public health officials.—VENARD.

ANTHROPOMORPHISM IN INSECT PSYCHOLOGY

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Students of comparative psychology know, or are soon made aware, that in the description of the behavior of animals the use of the familiar terms of man's mental activity is taboo. This attitude has become so general that writers, with few exceptions, take pains to cleanse their vocabulary of all such terms, lest they suffer the embarrassment of having their utterances called anthropomorphic. The word, originally borrowed from another field of interest, has grown not merely to have a technical meaning, but also to carry a connotation, an implication and an emotional atmosphere that is haughtily derogatory. Now, since a generation of young men have come to maturity in this atmosphere, it is quite natural that they should unthinkingly accept and share much of this attitude. Before continuing this course further, is it not fitting that we should pause and consider the validity of its claims?

Anthropomorphism, strictly speaking, means the endowing of a god with the form or attributes of man. The word has been slightly revamped to fill a need in scientific parlance. The meaning of the word, according to Darbishire[1] has been enlarged at both ends. It has been extended at the human end to the endowing of a god with attributes "which are more essentially human than the mere shape of man—namely, the way in which a man does things, and the kind of things he does." It has also been enlarged at the "endowed" end so as to mean the endowing of anything, usually some non-human living thing, with anything human. The extension of the word at this end came about during the nineteenth century, *pari passu* with a growth of a disbelief in God, especially among men of science. There was no god for them to endow with human attributes. It was a pity that a good long word like anthropomorphism should be wasted. So it was used to mean the endowing of anything non-human with any human attribute. You must not say that the lark sings for sheer joy, because that is an anthropomorphic interpretation of the song of the lark. Any ascription of purpose or intention, intelligence or design, to a non-human animal is condemned at once by contemporary orthodox biologists on the ground of its radical anthropomorphism.

There are apparently two schools that object to the use of anthropomorphic language in the study and interpretation of animal behavior: (1) those who wish to reserve purpose, intention, intelligence and design as attributes of man only, because the granting of the so-called human attributes to the infra-humans is repugnant to them; (2) those who "liked to think of the organism as a machine, and they liked their mechanical theory of evolution. . . . The belief that a non-human animal has an intelligence at all comparable to their own was branded

[1]An Introduction to a Biology, pp. 79–80, 1917.

with the word anthropomorphic and flung into the dust-bin of exploded superstititions."

The first school may be quickly answered by saying with Darbishire, "It is true that purpose, intention, intelligence and design are attributes of man. It does not follow from this that they are attributes of man *only*."

The attitude of the second school may be briefly summarized by quoting Forel[2] who refers to the works of "Bethe, Beer, Uexküll and Loeb, among others, who, in the name of the exact sciences, have disputed the possibility of a comparative psychology. In their opinion, everything must begin again; we have so far been only anthropomorphic. We have not any right to admit either sensations, perceptions or memories in animals. . . . It is necessary to remodel all the nomenclature, which is rotten with anthropomorphism. One will no longer be able to speak of vision, nor of smell, etc., among the beasts, but only of photoreflex or chemoreflex. The odour of the nest will be the substance of the nest; the combined individual, family and regional odour of the nest of bees will be consequently the substance of the individuo-regino-familio-nido-chemical reflex. What we have thought we have recognised as memories and associations will be the unknown forces A, B, C, D, etc."

Forel himself seeks the golden middle way, for in the preface of the same book we find him saying, "The whole question is, therefore, a chapter of comparative psychology, a chapter in which it is necessary to take careful note of every factor, to place oneself, so to say, on the level with the mind of an insect, and above all to avoid 'anthropocentric' errors with which works upon the subject are filled. At the same time, the other extreme must be equally avoided—'anthropophobia,' which at all costs desires to see in every living organism a 'machine,' forgetting that a 'machine' which lives, that is to say, which grows, takes nourishment, and strikes a balance between income and expenditure, which, in a word, continually reconstructs itself, is not a machine, but something entirely different. . . . In other words, we must steer clear of two dangers. We must avoid (1) identifying the insect mind with our own, and above all (2) imagining that we with what knowledge we possess, can reconstruct the mind by our chemical and physical laws."

Other students besides Forel who took exception to this pedantic attitude were Reaumur, Fabre, the Peckhams, Lubbock, Sladen, Rayment, McCook, Plath, and Frison. Outstanding among them is the late William Morton Wheeler, who often reported his findings in ant behavior in anthropomorphic language; he knew he was doing so, and on several occasions defended his attitude. In explaining his position in one place, he ironically acknowledged having committed "the eighth mortal sin." One can easily picture Wheeler smiling a quiet, private smile when he wrote that sentence, for the dictionary tells us that a mortal sin is a serious sin, aggravated by circumstances, and committed deliberately with the full consent of the will. Wheeler on other occa-

[2]The Senses of Insects. Tr. by M. Yearsley, p. 271, 1908.

sions sought to enlighten the critics of anthropomorphic usage who pedantically clung to the epithet evidently without fully knowing the history of the word. He wrote with logic and satire, but evidently without deep effect, for even today, after a lapse of twenty-five years, the literature of insect behavior still has a cramped style of expression because authors struggle to side-step the discredited type of expression in their writings, and editors continue to frown upon even minor anthropomorphisms in manuscripts.

Of course, it is readily admitted, an enthusiastic writer stands in danger of bringing into the recording of the behavior of his insects and animals exaggerated notions of their abilities. We hold no brief for such. On the other hand, it should be to the credit of the narrator if he circumvents boredom by relaxing into easy, forthright statements of his observations. It is indeed stupid for a writer to be required to qualify every phrase with an "I think," "it seems to me," or "to my mind." If a writer says "a bee chooses," "an ant decides" or "a wasp wishes," we should assume that he could have said, if he were sufficiently pedantic, "the bee behaves as if it chooses," "the ant acts as if it decided," and "the wasp performs as though it wished." Qualifications such as these make the writer all things to all men, and whatever the reader's turn of mind the writer will never be accused of placing the animal in the same psychic category with man. But in saving one's face one may hold back the fullest interpretation of animal behavior. In fact, one may thus help to perpetuate the mischief created by C. Lloyd Morgan in what is called Morgan's Canon or Morgan's Law of Parsimony, which, briefly summarized, holds that no act should be ascribed to a higher mental faculty if it can be accounted for in terms of a lower one.

It is quite clear that I am voicing a protest against the limitations which the mechanistic attitude imposes upon discussions of comparative psychology. Let me make it equally clear that I freely grant to the physiologists and to certain schools of the psychologists their own technical interpretation of the activities of the organism. Let them hold to the conclusion, if they will, that ultimately thought is a manifestation of chemical phenomena, and that physical bodies are resolved into terms of electrons responding to the influence of certain forces, etc.; let them build up a new vocabulary to express that concept for use in their own field. But let them keep the steam in their own boilers and avoid the error of trying to enforce the use of this highly specialized vocabulary in other fields. Let them grant to the observer of living, changing, struggling, exuberant creatures a vocabulary adequate to describe what he sees. The truth of one aspect of an organism does not cancel out the truth of another aspect of it, any more than an artist's interpretation of paints renders untrue the chemist's conception of the same paints. We can never hope to explain the *bios* of biology by establishing Blue-Laws about the language in which we speak of its wonders and mysteries. The mere replacing of old terms with new ones reveals only the observer, but throws no new light on the observed. Having summarily flung the thing out the door, we make haste to drag it back in through the window.

The loudest howlers against the use of anthropomorphic language in behavior studies are not the field naturalists, who study the organism in all its natural relations, but the physiologists, and the laboratory investigators, who keep their frantic quarry in miniature concentration camps in the laboratory, or as specimens steeped in alcohol. These latter men Goethe knew well a hundred years ago when he made his brilliant devil say:

> "He that would study and portray
> A living creature, thinks it fit
> To start with finding out the way
> To drive the spirit out of it.
> This done, he holds within his hand
> The pieces to be named and stated,
> But ah! the spirit-tie that spanned
> And knit them, has evaporated.
> This process, chemic science pleases
> To call *Naturae Encheiresis*,
> And in the very doing so, it
> Makes of itself a mock, and does not know it."

Studies and interpretations of animal behavior have not made greater progress because we have had too few Goethes and Wheelers to rebel against the domination of *bio*logy by the methods of physics and chemistry.

But Wheeler knew the strength of his position and he defends with valor the "writings tinged with anthropomorphism." Some of his remarks are indeed worth repeating for the benefit of students, and by reprinting them here we will bring them out of the oblivion of obscure places of publication. I beg leave to close with the following quotations.

In his book on The Social Insects (p. 3), Wheeler says, "The anthropomorphism attaching to the word 'social' is easily explained and may be condemned or condoned according to the general philosophical convictions of the critic. I can only record my belief that in the discussion of matters psychological, we can scarcely avoid a certain amount of anthropomorphism or teleology."

He has some interesting things to say on this matter when he reviews the book by Sladen on the Humble-Bee (Science, N. S. 37: 180–182, 1913). He comments on the fact that Sladen does not refer to the work of Wladimir Wagner on the same insects with the sonorous title of "Psychologische Untersuchungen Hummeln mit Bezugnahme auf die Frage der Geselligkeit im Tierreiche," and mischievously adds, "one familiar with this work may be pardoned if he secretly hopes that Sladen has never seen it, not because it is devoid of considerable merit, but because its spirit gives one reason to suspect that Sladen might have become sophisticated by its perusal. . . . In Sladen's work, the Humble-bee is the heroine of the story. She moves before us in all the glory of her regal velvety attire, with the joyous or apprehensive hum of incessant, arduous labor and self-sacrificing motherhood. In Wagner's account it is Wladimir Wagner who occupies the foreground as the

somewhat bumptious scientist who looks at the bumble-bee and makes an observation, forthwith settles its connection with some lop-sided hypotheses, incidentally belabors a few contrary-minded students of animal behavior. . . . Sladen on the other hand writes with charming insight and utterly unmindful of committing one of the most deadly sins that it is possible for a modern student of animal behavior to commit, pens such sentences as the following: 'The queen's *intelligence* is seen at its best while she is thus *caring* for her brood, and the *devotion* to it and her *alertness* on the slightest approach to danger are most interesting to witness. She shows no *desire* to escape unless she is severely molested and is quite *content* with her brood, *anxiously* incubating it day and night'." (Italics Wheeler's). And then by way of contrast, Wheeler quotes at length from Wagner's pompous story of the humble-bee, prefacing this quotation with: "This is the way Wagner, who is beset with the terrible anxiety lest he commit this deadly sin of 'grober Anthropomorphismus' describes the behavior."

Wheeler concludes with these enlightening remarks: "Such quotations reveal the differences between the two schools of animal behavior which they represent. To one the insect is a wonderful and inexhaustible living organism, whose activities can be most satisfactorily described in the language which we employ when speaking of another individual of our own species; to the other the insect is a pure mechanism whose every movement is easily expounded by the observer, who stands in the foreground and uses the observed object largely as a means of displaying his own analytical and explanatory acumen."

In his work On Instincts,[3] he comments as follows: The anthropomorphic view of instinct is "essentially a recognition of the fundamental identity of the animal and human soul, the differences between which are regarded merely as differences of degree of development. This implies that intelligence is not exclusively human and that the animal mind is to be interpreted in the light of human psychology, a procedure which is, of course, open to the charge of anthropomorphism. But owing to the fact that all our science is necessarily anthropomorphic and that man himself is merely a highly developed animal and therefore could not if he would interpret other animals except in terms of himself, the charge can only mean that he continually runs the risk of attributing to animals a greater development of intelligence than they possess. As scientific methods of observation and experiment are quite adequate for the control and rectification of this tendency, it is impossible to regard anthropomorphism as such a very terrible eighth mortal sin."

Apparently also everything is not quite kosher in the camp of students of human psychology in respect to this matter of anthropomorphism, and the remarks by Dr. D. B. Klein in an article entitled "Scientific Understanding in Psychology"[4] may serve as underpinning for the views of both Wheeler and Darbishire. " . . . the psychologist made a tactical blunder in his efforts to place the study of mental phenomena on a scientific basis. He followed the pattern of the natural

[3]Essays in Philosophical Biology, pp. 47–48, 1939.

[4]Psychological Review, 39: 552–569, 1932.

sciences too slavishly. He seems to have reasoned that since it was necessary for these sciences to purge themselves of all vestiges of anthropomorphism, his science must do the same, and although it may sound heretical, we feel constrained to say that this is precisely what he should not have done. He alone was justified in making his science anthropomorphic. To argue that the study of human nature must be devoid of anthropomorphic interpretation is akin to urging the chemist to steer clear of chemical interpretations. . . . To be scientific, psychology must become more anthropomorphic, not less so, paradoxical and tautological as this may sound."

It logically follows that, if anthropomorphic interpretation is necessary for the study of human behavior, it is also necessary for the study of the other animals; and as undercurrents of dissatisfaction such as Klein's come more and more to the surface, students will know that if Wheeler sinned in the pioneering for a place for anthropomorphism in the literature of animal behavior,

"Some rise by sin, and some by virtue fall."
—*Shakespeare.*

ANOPHELES GAMBIAE IN BRAZIL 1930–1940, by FRED L. SOPER and D. BRUCE WILSON. xviii+262 pages, 49 tables, 5 plates, 75 figures. The Rockefeller Foundation, 49 W. 49th Street, New York 20.

The fight in Brazil against *Anopheles gambiae* has received widespread publicity and, therefore, this complete account of the battle will be eagerly read by entomologists. It will be particularly valuable to medical entomologists and to those individuals interested in the theory and practice of species eradication of insect pests.

The nature of the book is well illustrated by the titles in the table of contents which are: Introduction; The Invader; Description of *Anopheles gambiae;* The Region Invaded; Early Results of *gambiae* Invasion; The Silent Era, 1932 to 1937; Invasion of More Favorable Regions; Epidemic malaria in the Northeast; Surveys and Control Measures; The Malaria Service in the Northeast; Spread and Retreat of *gambiae*, 1937 to 1940; Spread and Recession of Malaria, 1939 to 1941, in *gambiae* Infested Region; Statistical Summary of the Malaria Service of the Northeast; Special Sections; Discussion; Summary; Appendix I; Appendix II; Appendix III; Bibliography, and Index.

Dr. Raymond B. Fosdick has recently reported (The Rockefeller Foundation. A Review for 1943) that *anopheles gambiae* is again in Brazil. This information will give fuel for discussions as to whether the mosquito was eradicated. The evidence that the mosquito was eliminated is convincing and although it was originally introduced to Brazil from Natal by a fast destroyer it has been found on airplanes several times and in this way there has been opportunity for reinfestation.

There is no reason to assume that this mosquito could not live in our Gulf States and due to our air service with Africa we should be on the alert for the introduction of *A. gambiae.* Additional reasons for becoming familiar with the contents of this book are that it is a thrilling account of an important chapter in the history of a man's fight against malaria and the methods used in eliminating *A. gambiae* are given in detail.

There is no charge for this book and its distribution is to doctors and public health officials.—VENARD.

THE FLEAS (SIPHONAPTERA) OF ALBERTA, WITH A LIST OF THE KNOWN VECTORS OF SYLVATIC PLAGUE

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and
Director of the Alberta Sylvatic Plague Survey

Sylvatic plague, the type of bubonic plague that occurs in rural areas, has been demonstrated to be present in Central Alberta. It mainly affects rodents but can be readily transmitted to man, to whom it is usually fatal. The Alberta Sylvatic Plague Survey, organized in the spring of 1938 under the auspices of the Alberta Department of Public Health, has been shooting and trapping small rodents in Alberta, and examining them for the presence of plague lesions; the fleas present on these rodents have also been collected, and examined for the possible presence of plague.

The following list of Alberta Siphonaptera has been compiled from records published by Rothschild and Jordan, and from named material in the University of Alberta collection. All of the specimens in the University collection were collected by the author during the course of the Alberta Sylvatic Plague Survey.

In listing the species particular attention has been paid to recording hosts and distribution, so that a comprehensive picture of the flea situation in Alberta might be obtained. As the order Siphonaptera is in a state of chaos, the species in Alberta have been listed under the names recorded by Ewing and Fox (2) and by Jellison and Good (3). Specimens in the University of Alberta collection are designated by (1). The names preceded by an asterisk (*) are the names under which the species were previously reported from Alberta.

The plague vectors together with their hosts, as recorded by Eskey and Haas (6) and known to be present in Alberta, are listed separately. (See numbered references at end of article.)

LIST OF THE SIPHONAPTERA OF ALBERTA

1. **Amphalius necopinus** (Jordan), 1925, (2, 5).
   Host.—Pika or rock-rabbit (*Ochotona princeps*).
   Locality.—Banff.
2. **Amphipsylla sibirica pollionis** (Roths.), 1905, (2, 3).
   **Ceratophyllus pollionis* Roths., by Rothschild in 1903, (3).
   Hosts.—Meadow mouse (*Microtus drummondi*), red-backed mouse (*Evotomys gapperi saturatus*).
   Locality.—Red Deer.
3. **Arctopsylla ursi** (Roths.), 1902, (2).
   **Pulex ursi* Roths., by Rothschild in 1902, (3).
   Host.—Grizzly bear (*Ursus horribilis*).
   Locality.—West of Calgary.
4. **Catallagia borealis** Ewing, 1929, (2, 4).
   Host.—Short-tailed shrew (*Blarina brevicauda*).
   Locality.—Alberta.

5. **Catallagia charlottensis** (Baker), 1898, (2).
   **Ceratophyllus charlottensis* (Baker), by Rothschild in 1905, (3).
   Hosts.—White-footed deer mouse (*Peromyscus leucopus*), wood rat (*Neotoma cinerea*), red-backed mouse (*Evotomys gapperi saturatus*).
   Locality.—Alberta.

6. **Catallagia decipiens** Roths., 1915, (2, 3).
   Hosts.—Red-backed mouse (*Evotomys gapperi saturatus*), Columbian ground squirrel (*Citellus columbianus*).
   Localities.—Red Deer, Blackfalds.

7. **Cediopsylla inaequalis inaequalis** (Baker), 1895, (1).
   Cediopsylla (*Acediopsylla*) *inaequalis inaequalis* (Baker), (2).
   Host.—Jack-rabbit (*Lepus* sp.).
   Locality.—Orion.

8. **Ceratophyllus garei** Roths., 1902, (2, 3).
   **Ceratophyllus garei* Roths., by Jordan and Rothschild, 1920.
   **Ceratophyllus garei* Roths., by Jordan 1929.
   Hosts.—Geese (Anserinae), white-winged scoter (*Melanitta deglandi*), and other avian hosts.
   Locality.—Edmonton.

9. **Ceratophyllus niger** C. Fox, 1908, (2).
   Ceratophyllus niger niger Fox, 1908, (3).
   **Ceratophyllus niger niger* Fox, by Jordan, 1929.
   Hosts.—Turkey (*Meleagris gallopavo*), domestic fowl (*Gallus domesticus*).
   Locality.—Alberta.

10. **Corrodopsylla curvata curvata** (Roths.), 1936, (2, 3).
    **Doratopsylla curvata curvata* Roths., by Rothschild, 1915.
    Hosts.—Kangaroo mouse (*Zapus hudsonius*), shrew (*Sorex* sp.).
    Locality.—Blackfalds.

11. **Ctenocephalides canis** (Curtis), 1826, (1, 2, 3).
    Hosts.—Cat (*Felis catus*), dog (*Canis familiaris*).
    Locality.—Edmonton.

12. **Ctenocephalides felis felis** (Bouché), 1835, (2, 3, 1).
    Host.—Cat (*Felis catus*).
    Locality.—Edmonton.

13. **Ctenophthalmus pseudagyrtes** Baker, 1904, (2, 3).
    **Ctenophthalmus pseudagyrtes* Baker, by Rothschild, 1904.
    Hosts.—Meadow mouse (*Microtus drummondi*), red-backed mouse (*Evotomus gapperi saturatus*).
    Locality.—Red Deer.

14. **Ctenophyllus terribilis** (Roths.), 1903, (2, 3).
    **Ceratophyllus terribilis* Roths., by Rothschild, 1903.
    Host.—Pika or rock-rabbit (*Ochotona princeps*).
    Locality.—Banff.

15. **Dactylopsylla (Foxella) ignota albertensis** (J. & R.), 1915, (1, 2).
    Foxella ignota albertensis (J. & R.), 1915, (3).
    **Ceratophyllus ignotus albertensis* J. & R., by Jordan and Rothschild, 1915 (3).
    Hosts.—Pocket gopher (*Geomys* sp.), weasel (*Mustela* sp.), Canada lynx (*Lynx canadensis*).
    Localities.—Blackfalds, Waterton, Camrose, Winterburn.

16. **Delotelis telegoni** (Roths.), 1905, (2, 3).
    **Ceratophyllus telegoni* Roths., by Rothschild, 1905.
    Hosts.—Meadow mouse (*Microtus drummondi*), red-backed mouse (*Evotomys gapperi*).
    Locality.—Kicking Horse Canyon.

17. **Epitedia inopina** (Roths.), 1915, (2).

24. * *Neopsylla inopina* Roths., by Rothschild, 1915, (3).
    Host.—Richardson's ground squirrel (*Citellus richardsonii*).
    Locality.—Calgary.

18. **Epitedia wenmanni** (Roths.) 1904 (2, 3).
**Neopsylla wenmanni* (Roths.), by Jordan 1929.
Hosts.—White-footed mouse (*Peromyscus leucopus*).
Locality.—Alberta.

19. **Hoplopsyllus (Euhoplopsyllus)** sp. (Baker) 1905 (1, 2).
Host.—Snow-shoe rabbit (*Lepus* sp.).
Locality.—Waterton.

20. **Hystrichopsylla gigas dippiei** Roths. 1902 (1, 2, 3).
**Hystrichopsylla dippiei* Roths., by Rothschild 1902.
Hosts.—Weasel (*Mustela frenata longicauda*), jack-rabbit (*Lepus* sp.), pocket gopher (*Thomomys fuscus*).
Localities.—Alberta, Stanmore.

21. **Megarthroglossus divisus divisus** (Baker) 1898 (2, 3).
**Megarthroglossus longispinus* (Baker), by Rothschild 1915.
Hosts.—Red squirrel (*Sciurus richardsoni baileyi*), mouse (*Mus* sp.).
Locality.—Red Deer River (Rocky Mountains).

22. **Nearctopsylla brooksi** (Roths.) 1904 (2, 3).
**Ctenopsyllus brooksi* Roths., by Rothschild 1904.
Hosts.—Richardson's weasel (*Mustela cicognani richardsoni*), long-tailed weasel (*Mustela longicauda*).
Locality.—Calgary.

23. **Nearctopsylla genalis genalis** (Baker) 1904 (2, 3).
Nearctopsylla hygini hygini (Roths.) 1904 (3).
**Ctenopsyllus hygini hygini* Roths., by Rothschild 1904.
Hosts.—Richardson's weasel (*Mustela cicognani richardsoni*).
Locality.—Red Deer.

24. **Neopsylla inopina** Roths., of Rothschild 1915 (1, 3).

17. **Epitedia inopina* (Roths.) 1915 (2).
Hosts.—Richardson's ground squirrel (*Citellus richardsonii*), long-tailed weasel (*Mustela longicauda*), red-backed mouse (*Evotomys gapperi saturatus*).
Localities.—Calgary, Waterton, Stanmore.

25. **Odontopsyllus multispinosus** (Baker) 1898 (1, 2).
Host.—Cotton-tail rabbit (*Sylvilagus* sp.).
Locality.—Alberta.

26. **Orchopeas caedens** (Jordan) 1925 (2).
Orchopeas caedens (Jordan) 1925 (3).
**Ceratophyllus caedens* Jordan, by Jordan 1925.
Host.—Marten (*Martes americana*).
Locality.—Banff.

27. **Orchopeas leucopus** (Baker). 1904 (2, 3).
**Ceratophyllus ager* Roths., by Rothschild 1905.
**Ceratophyllus leucopus* Baker, by Jordan, 1929.
Hosts.—White-footed mouse (*Peromyscus maniculatus borealis*), red-backed mouse (*Evotomys gapperi saturatus*).
Locality.—Red Deer.

28. **Orchopeas sexdentatus agilis** (Roths.) 1905 (2, 3).
**Ceratophyllus agilis* Roths., by Rothschild 1905.
**Ceratophyllus sexdentatus agilis* Roths., by Jordan 1929.
Hosts.—Wood rat (*Neotoma cinerea*), pika or rock-rabbit (*Ochotona princeps*), Richardson's red squirrel (*Sciurus hudsonicus richardsoni*), long-tailed weasel (*Mustela longicauda*).
Localities.—Banff, Red Deer.

29. **Oropsylla (Opisocrostis) bruneri** (Baker) 1895 (1, 2).
Opisocrostis bruneri (Baker) 1895 (3).
Hosts.—Richardson's ground squirrel (*Citellus richardsonii*), Columbian ground squirrel (*Citellus columbianus*), 13-striped ground squirrel (*Citellus tridecemlineatus*).
Localities.—Sunnynook, Waterton.

30. **Oropsylla (Opisocrostis) labis** (Jordan & Roths.) 1922 (1, 2).
Opisocrostis labis (Jordan & Roths.) 1922 (3).
**Ceratophyllus labis* Jordan & Roths., by Jordan and Rothschild 1922.
Host.—Weasel (*Mustela longicauda*).
Locality.—Calgary.

31. **Oropsylla (Opisocrostis) tuberculata tuberculata** (Baker) 1904 (1, 2).
Opisocrostis tuberculatus tuberculatus (Baker) 1904.
Hosts.—Columbian ground squirrel (*Citellus columbianus*), Richardson's ground squirrel (*Citellus richardsonii*), jack-rabbit (*Lepus* sp.).
Localities.—Edmonton, Stanmore, Camrose, Youngstown, Manyberries, Brooks.

32. **Oropsylla (Oropsylla) arctomys** (Baker) 1904 (1, 2).
Oropsylla arctomys (Baker) 1904 (3).
Host.—Richardson's ground squirrel (*Citellus richardsonii*).
Locality.—Stanmore.

33. **Oropsylla (Oropsylla) idahoensis** (Baker) 1904 (1, 2).
Oropsylla idahoensis (Baker) 1904 (3).
**Ceratophyllus poeantis* Roths., by Rothschild 1905.
Hosts.—Long-tailed weasel (*Mustela longicauda*), weasel (*Mustela* sp.), Richardson's ground squirrel (*Citellus richardsonii*), Say's mountain chipmunk (*Eutamias* sp.), burrowing owl (*Speotyto cunicularia*), mountain gopher (*Citellus* sp.), Columbian ground squirrel (*Citellus columbianus*).
Localities.—Banff, Red Deer River, Atlee, Manyberries, Camrose, Stanmore.

34. **Oropsylla (Oropsylla) rupestris** (Jordan) 1929 (1, 2).
Oropsylla rupestris (Jordan) (3).
**Ceratophyllus rupestris* Jordan 1929, by Jordan 1929.
Hosts.—Weasel (*Mustela longicauda*), Richardson's ground squirrel (*Citellus richardsonii*), badger (*Taxidea taxus*), pocket gopher (*Thomomys* sp.).
Localities.—Calgary, Lethbridge, Stanmore, Atlee, Waterton, Camrose, Youngstown, Sunnynook, Blackfalds, Dorothy.

35. **Peromyscopsylla hamifer hamifer** (Roths.) 1906 (2, 3).
**Ctenopsyllus hamifer* Roths., by Rothschild 1906.
Host.—Weasel (*Mustela* sp.).
Locality.—Blackfalds.

36. **Peromyscopsylla selenis** (Roths.) 1906 (2, 3).
**Ctenopsyllus selenis* Roths., by Rothschild 1906.
Hosts.—Red-backed mouse (*Evotomys gapperi*), kangaroo mouse (*Zapus hudsonius*).
Localities.—Red Deer, Blackfalds.

37. **Pulex irritans** Linnaeus (1, 2, 3).
**Pulex irritans* L., by Jordan and Rothschild 1908.
Hosts.—In house; child; lynx (*Lynx canadensis*), fox (*Vulpes velox*), badger (*Taxidea taxus*).
Localities.—Vega, Dewberry, Stanmore, Edmonton, Mirror Landing.

38. **Rectofrontia fraterna** (Baker) 1895 (1, 2, 3).
**Rectofrontia fraterna* (Baker), by Jordan 1937.
Host.—Burrowing owl (*Speotyto cunicularia*).
Locality.—Dobson.

39. **Tamiophila grandis** (Roths.) 1902 (1, 2).
Hosts.—Columbian ground squirrel (*Citellus columbianus*), Richardson's ground squirrel (*Citellus richardsonii*).
Locality.—Stanmore.

40. **Thrassis acamantis** (Roths.) 1905 (1, 2).
Host.—Marmot (*Marmota flaviventris avara*).
Locality.—Waterton.

41. **Thrassis bacchi** (Roths.) 1905 (2, 3).
**Ceratophyllus bacchi* Roths., by Rothschild 1905.
Host.—Thirteen-striped ground squirrel (*Citellus tridecemlineatus*).
Locality.—Red Deer.

42. **Thrassis gladiolis gladiolis** (Jordan) 1925 (1, 2, 3).
Host.—Thirteen-striped ground squirrel (*Citellus tridecemlineatus*).
Locality.—Squaw Butte.

43. **Thrassis petiolatus** (Baker) 1904 (1, 2, 3).
Host.—Columbian ground squirrel (*Citellus columbianus*).
Locality.—Waterton.

44. **Trichopsylla (Trichopsylla) abantis** (Roths.) 1905 (2).
Megabothris abantis (Roths.) (3).
**Ceratophyllus abantis* Roths., by Rothschild 1905.
Host.—Long-tailed weasel (*Mustela longicauda*).
Locality.—Canadian National Park, Alberta.

45. **Trichopsylla (Trichopsylla) asio asio** (Baker) 1904 (2).
**Megabothris asio asio* Baker, by Jordan 1933 (1).
Host.—Weasel (*Mustela* sp.).
Locality.—Hanna.

46. **Trichopsylla (Trichopsylla) atrox** (Jordan) 1925 (2).
Megabothris atrox (Jordan) 1933 (3).
**Ceratophyllus atrox* Jordan, by Jordan 1925.
Host.—Weasel (*Mustela* sp.).
Locality.—Blackfalds.

47. **Trichopsylla (Trichopsylla) bitterrootensis** (Dunn) 1923 (2).
Malareus bitterrootensis (Dunn) 1923 (3).
**Ceratophyllus isus* Jordan, by Jordan 1925.
Host.—Mouse (*Mus* sp.).
Locality.—Red Deer River (Canadian Rockies).

48. **Trichopsylla (Trichopsylla) eumolpi eumolpi** (Roths.) 1905 (1, 2).
Monopsyllus eumolpi eumolpi (Roths.) 1905 (3).
**Ceratophyllus eumolpi* Roths., by Rothschild 1905.
Host.—Western chipmunk (*Eutamias* sp.).
Localities.—Banff, Red Deer, Waterton.

49. **Trichopsylla (Trichopsylla) lucifer** (Roths.) 1905 (2).
Megabothris lucifer (Roths.) 1905 (3).
**Ceratophyllus lucifer* Roths., by Rothschild 1905.
Host.—Meadow mouse (*Microtus drummondi*).
Locality.—Red Deer.

50. **Trichopsylla (Trichopsylla) quirini** (Roths.) 1905 (2).
Megabothris quirini (Roths.) 1905 (3).
**Ceratophyllus quirini* Roths., by Rothschild 1905.
Hosts.—Red-backed mouse (*Evotomys gapperi*), red-backed mouse (*Evotomys gapperi saturatus*).
Locality.—Red Deer.

51. **Trichopsylla (Trichopsylla) thamba** (Jordan) 1929 (2).
Monopsyllus thambus (Jordan) 1929 (3).
**Ceratophyllus thambus* Jordan, by Jordan 1929.
Host.—Lynx (*Lynx canadensis*).
Locality.—Red Deer.

52. **Trichopsylla (Trichopsylla) vison** (Baker) 1904 (1, 2).
Monopsyllus vison (Baker) 1904 (3).
**Ceratophyllus vison* Baker, by Jordan 1929.
Hosts.—Chipmunk (*Eutamias* sp.), pine squirrel (*Sciurus hudsonicus*).
Locality.—Waterton, Alberta.

53. **Trichopsylla (Trichopsylla) wagneri systalta** (Jordan) 1929 (1, 2).
Monopsyllus wagneri systaltus (Jordan) 1929 (3).
**Ceratophyllus wagneri systaltus* Jordan, by Jordan 1929.
Host.—White-footed mouse (*Peromyscus* sp.).
Localities.—Red Deer, Blackfalds, Waterton.

A LIST OF KNOWN PLAGUE VECTORS

1. **Orchopeas sexdentatus agilis** (Roths.) 1905.
   Hosts.—Wood rat (*Neotoma cinerea*), pika or rock-rabbit (*Ochotona princeps*), Richardson's red squirrel (*Sciurus richardsoni*), long-tailed weasel (*Mustela longicauda*).
   Localities.—Banff, Red Deer.
2. **Oropsylla (Oropsylla) idahoensis** (Baker) 1904.
   Hosts.—Long-tailed weasel (*Mustela longicauda*), weasel (*Mustela* sp.), Richardson's ground squirrel (*Citellus richardsonii*), Say's mountain chipmunk (*Eutamias* sp.), burrowing owl (*Speotyto cunicularia*), mountain gopher (*Citellus* sp.), Columbian ground squirrel (*Citellus columbianus*).
   Localities.—Banff, Red Deer River, Atlee, Manyberries, Camrose, Stanmore.
3. **Oropsylla (Opisocrostis) labis** (Jordan & Roths.) 1922.
   Host.—Weasel (*Mustela longicauda*).
   Locality.—Calgary.
4. **Oropsylla (Oropsylla) rupestris** (Jordan) 1929.
   Hosts.—Weasel (*Mustela* sp.), Richardson's ground squirrel (*Citellus richardsonii*), badger (*Taxidea taxus*), pocket gopher (*Thomomys* sp.).
   Localities.—Calgary, Lethbridge, Stanmore, Atlee, Waterton, Camrose, Youngstown, Sunnynook, Blackfalds, Dorothy.
5. **Oropsylla (Opisocrostis) tuberculata tuberculata** (Baker) 1904.
   Hosts.—Columbian ground squirrel (*Citellus columbianus*), Richardson's ground squirrel (*Citellus richardsonii*), jack-rabbit (*Lepus* sp.).
   Localities.—Edmonton, Stanmore, Camrose, Youngstown, Manyberries, Brooks.
6. **Pulex irritans** Linnaeus 1758.
   Hosts.—In house; child; lynx (*Lynx canadensis*), fox (*Vulpes velox*), badger (*Taxidea taxus*).
   Localities.—Vega, Dewberry, Stanmore, Edmonton, Mirror Landing.
7. **Thrassis acamantis** (Roths.) 1905.
   Host.—Marmot (*Marmota flaviventris avara*).
   Locality.—Waterton.
8. **Thrassis gladiolis gladiolis** (Jordan) 1925.
   Host.—Thirteen-striped ground squirrel (*Citellus tridecemlineatus*).
   Locality.—Squaw Butte.
9. **Thrassis petiolatus** (Baker) 1904.
   Host.—Columbian ground squirrel (*Citellus columbianus*).
   Locality.—Waterton.
10. **Trichopsylla (Trichopsylla) eumolpi eumolpi** (Roths.) 1905.
    Host.—Western chipmunk (*Eutamias* sp.).
    Localities.—Banff, Red Deer, Waterton.
11. **Trichopsylla (Trichopsylla) thamba** (Jordan).
    Host.—Lynx (*Lynx canadensis*).
    Locality.—Red Deer.

A LIST OF HOSTS FROM WHICH PLAGUE VECTORS HAVE BEEN RECOVERED

1. **Badger** (*Taxidea taxus*).
   Vectors: *Oropsylla* (*Oropsylla*) *ruprestris* Jordan 1929.
   Pulex irritans Linnaeus 1758.
2. **Burrowing owl** (*Speotyto cunicularia*).
   Vectors: *Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.
3. **Child.**
   Vector: *Pulex irritans* Linnaeus 1758.
4. **Columbian ground squirrel** (*Citellus columbianus*).
   Vectors: *Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.
   Oropsylla (*Opisocrostis*) *tuberculata tuberculata* Baker 1904.
   Thrassis petiolatus Baker 1904.

5. **Coyote** (*Canis latrans*).
   Vector: *Oropsylla* (*Oropsylla*) *rupestris* Jordan 1929.
6. **Fox** (*Vulpes velox*).
   Vector: *Pulex irritans* Linnaeus 1758.
7. **Jack-rabbit** (*Lepus* sp.).
   Vector: *Orospylla* (*Opisocrostis*) *tuberculata tuberculata* Baker 1904.
8. **Lynx** (*Lynx canadensis*).
   Vectors: *Pulex irritans* Linnaeus 1758.
   Trichopsylla (*Trichopsylla*) *thamba* Jordan 1929.
9. **Marmot** (*Marmota flaviventris avara*).
   Vector: *Thrassis acamantis* Rothschild 1905.
10. **Pocket gopher** (*Thomomys* sp.).
    Vector: *Oropsylla* (*Oropsylla*) *rupestris* Jordan 1929.
11. **Richardson's ground squirrel** (*Citellus richardsonii*).
    Vectors: *Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.
    Oropsylla (*Oropsylla*) *rupestris* Jordan 1929.
    Oropsylla (*Opisocrostis*) *tuberculata tuberculata* Baker 1904.
12. **Richardson's red squirrel** (*Sciurus richardsoni*).
    Vector: *Orchopeas sexdentatus agilis* Roths. 1905.
13. **Rock-rabbit or pika** (*Ochotona princeps*).
    Vector: *Orchopeas sexdentatus agilis* Roths. 1905.
14. **Say's mountain chipmunk** (*Eutamias* sp.).
    Vectors: *Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.
    Trichopsylla (*Trichopsylla*) *eumolpi eumolpi* Roths. 1905.
15. **Weasel** (*Mustela* sp.).
    Vectors: *Orchopeas sexdentatus agilis* Roths. 1904.
    Oropsylla (*Oropsylla*) *idahoensis* Baker 1904.
    Oropsylla (*Opisocrostis*) *labis* Jordan & Roths. 1922.
    Oropsylla (*Oropsylla*) *rupestris* Jordan 1929.
16. **Wood rat** (*Neotoma cinerea*).
    Vector: *Orchopeas sexdentatus agilis* Roths. 1905.
17. **Thirteen-striped ground squirrel** (*Citellus tridecemlineatus*).
    Vector: *Thrassis gladiolis gladiolis* Jordan 1925.

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HEAD-CAPSULE MEASUREMENTS OF SOUTHERN ARMYWORM LARVAE (PRODENIA ERIDANIA (CRAMER))

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The observation by Dyar (1890) that the sclerotized parts of insects do not change in area during a stadium but increase only at ecdysis led to the generalization that the changes in width of the head capsule of a larva in its successive stages usually follow a regular geometric progression, and this generalization has become known as Dyar's rule. This rule has been used by Taylor (1931), Gaines and Campbell (1935), Peterson and Haeussler (1928), and others to determine the number of instars undergone by certain larvae and also to determine if the observed number of molts coincided with the number required if Dyar's rule was applicable.

The width of the head capsule of each larval instar of the southern armyworm (*Prodenia eridania* (Cram.)) was given in a technical description of the egg and larval stages of this insect, contributed by Dyar for inclusion in a publication by Chittenden and Russell (1909). His figures were obtained by measuring the head width of a relatively few larvae that were collected in the field.

Large numbers of southern armyworm larvae that were reared in greenhouse cages have been used in the laboratories of the Division of Control Investigations at Beltsville, Md., for various physiological and toxicological experiments, and it has become increasingly necessary to be able to determine the instar to which a given larva belongs. With this purpose in mind, and also to determine if the head measurements given in the publication by Chittenden and Russell are applicable to these greenhouse-reared larvae, the widths of the head capsules of over two thousand larvae of all ages and sizes have been determined. The present paper is based on these measurements and their statistical analysis.

METHODS

In the laboratories previously mentioned, the young southern armyworm larvae are normally placed on turnip foliage immediately after they have hatched and remain on this foodstuff until they are about 10 days old, after which they are fed collard leaves until feeding ceases. The larvae are kept in greenhouse cages that are maintained at 75° to 85° F. during the winter months by the use of soil-heating cables in the bottoms of the cages. During the summer no temperature control is attempted. For the purposes of these experiments some larvae were fed in the normal manner, others were reared through on turnip foliage alone, and still others were reared in individual containers so that the head sizes of single larvae could be determined throughout the

larval cycle. The size of the cast head capsules of these last larvae were compared with the size of the head before molting took place.

All measurements were made by the use of a calibrated ocular micrometer.

RESULTS, CALCULATIONS, AND DISCUSSION

The widths of the head capsules of all larvae measured ranged between 0.2424 and 2.9896 mm. Figure 1 shows the results of grouping all larvae, except those reared in individual containers, according to head-capsule size, each group representing an instar.

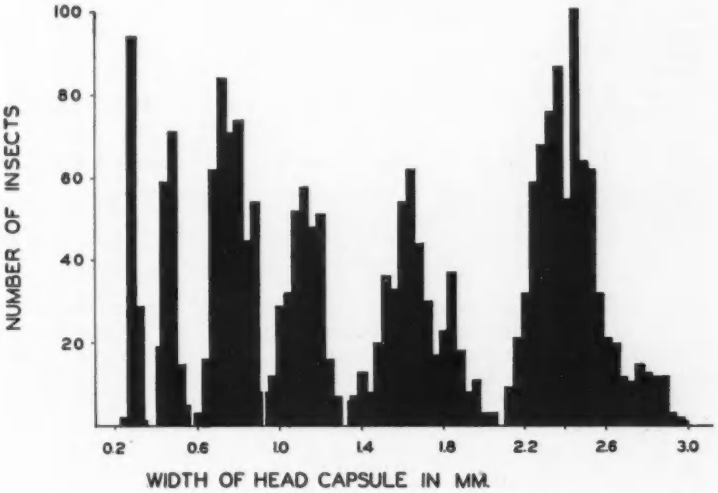

FIGURE 1. Histogram showing frequency distribution of head-capsule widths of the southern armyworm.

The mean head width of each instar was then determined and the growth ratio was found by dividing each mean by the mean preceding it. According to statistical theory (Fisher, 1930), a deviation exceeding 1 standard deviation occurs about once in 3 trials, and twice the standard deviation is exceeded only about once in 22 trials. In an effort, therefore, to determine the possible limits of each instar, the mean ± 1 standard deviation and the mean ± 2 standard deviations were determined. The results are shown in Table I.

It is apparent that there are six well-defined groups, or instars, but it must be noted that in four instars, the first, second, third, and fifth, the observed limits of the instar are exceeded by neither the upper nor the lower limit of two standard deviations from the mean. For this reason, when a larva of a given instar is desired, the practice has been adopted of selecting only those whose head-capsule measurements are

within one standard deviation of the mean for that instar. The instar sizes of field-collected larvae as given by Dyar in the publication by Chittenden and Russell correspond closely with those found in this laboratory.

TABLE I

DATA CONCERNING HEAD-CAPSULE WIDTHS AND INSTARS OF THE SOUTHERN ARMYWORM

Instar Number	1	2	3	4	5	6
Observed limits of instar (mm.)	0.24–0.34	0.40–0.59	0.61–0.91	0.93–1.27	1.29–2.06	2.10–2.99
Mean (mm.)	.29	.47	.77	1.11	1.66	2.41
Growth ratio	.....	1.62	1.65	1.45	1.49	1.45
Standard deviation (mm.)	.016	.037	.066	.083	.148	.171
Limits of M ± 1 standard deviation (mm.)	.27–.31	.43–.51	.70–.84	1.03–1.19	1.51–1.81	2.24–2.58
Limits of M ± 2 standard deviations (mm.)	.26–.32	.40–.54	.64–.90	.94–1.28	1.38–1.94	2.07–2.75
Number of individuals observed	126	170	407	311	436	788
Duration of instar (days)	5	3.5	3	3	5	8.5

In an experiment head-capsule measurements were made on a number of live larvae, some on cast head capsules, and some others on larvae that had been preserved in alcohol. For a given instar no significant difference in size between these three groups was found. In Table II measurements are given of cast head capsules of 100 larvae that were reared through to pupation in small individual containers.

TABLE II

DATA ON 100 SOUTHERN ARMYWORM LARVAE REARED ENTIRELY ON TURNIP FOLIAGE IN INDIVIDUAL CONTAINERS

Instar number	1	2	3	4	5	6
Mean width of head capsule of cast skin of 98 larvae, in mm	0.28	0.46	0.75	1.18	1.82	2.77
Growth ratio	.....	1.64	1.63	1.58	1.54	1.53
Mean width of the head capsule of the cast skin of two larvae that pupated after 5 instars	0.26	0.44	0.78	1.27	2.30	pupa

These were fed turnip foliage only. Two of these larvae, however, pupated at the end of five instars instead of the normal six. The mean measurement for the first instar of these two abnormal larvae is 0.01 mm. below the lower limit of the mean ± 1 standard deviation found in Table I for the corresponding instar. The second and third lie between these limits but the fourth and fifth were considerably at variance.

That food is apparently an important factor is shown by the variation in growth ratios soon after the larvae begin feeding on collards, the growth ratios for the turnip-leaf-fed fifth and sixth instars being considerably above those of the larvae that were fed collards after the third instar. Since this observation is based on the behavior of only 100 larvae, however, it may not be generally correct.

If Dyar's rule is strictly correct, the growth ratios for all instars should be the same, and any irregularity in the progression would denote the omission of an instar. There is considerable variation in the

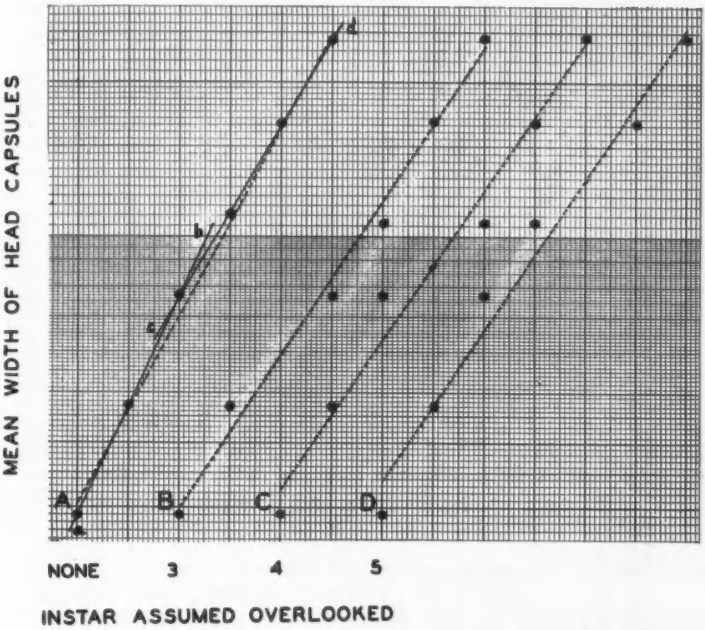

FIGURE 2. Relation of calculated progression to observed head measurements (graph made on semi-log paper). The dotted line *A* is the line of best fit for the observed measurements, calculated from the equation log Y= log a+(log b) X. The dotted lines *B*, *C*, and *D* are calculated in a similar manner but under the assumption that the third, fourth, and fifth instars, respectively, had been overlooked. The lines *ab* and *cd* show the departure of the observed values for the third instar from a geometric progression.

growth ratios of the various instars, as is shown in Tables I and II, but not so much as was found by Gaines and Campbell (1935) in their work on the corn earworm. These authors pointed out that if the head widths were in a geometrical progression, the best estimate of the growth ratio would be obtained by converting the measurements to logarithms and by the method of least squares determining the constants a and b of the equation log Y=log a+(log b)X. In this equation antilog Y is the

TABLE III

COMPARISON OF OBSERVED AND CALCULATED VALUES, IN MILLIMETERS, OF THE MEAN WIDTH OF THE HEAD CAPSULE OF THE SOUTHERN ARMYWORM, WHEN IT WAS ASSUMED THAT SUCCESSIVE INSTARS HAD BEEN OVERLOOKED

Instar Assumed to Have Been Overlooked		First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Sixth Instar	Seventh Instar	Standard Error of Estimate	Mean Growth Ratio
		Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	
None	Observed mean	0.286	0.465	0.769	1.114	1.658	2.409	.....	.....	.....
	Calculated mean	.304	.465	.710	1.084	1.657	2.531	.....	.....	.....
	Difference	— .018	0	+ .059	+ .030	+ .001	— .122	.....	0.066	1.53
Second	Observed mean	.286	.....	.465	.769	1.114	1.658	2.409	.....	.....
	Calculated mean	.259	.374	.539	.776	1.119	1.614	2.327	.....	.....
	Difference	+ .027	.....	— .074	— .007	— .005	+ .044	+ .082	0.061	1.44
Third	Observed mean	.286	.465	.....	.769	1.114	1.658	2.409	.....	.....
	Calculated mean	.297	.418	.589	.829	1.166	1.642	2.311	.....	.....
	Difference	— .011	+ .047	.....	— .060	— .052	+ .016	+ .098	0.068	1.41
Fourth	Observed mean	.286	.465	.769	.....	1.114	1.658	2.409	.....	.....
	Calculated mean	.324	.451	.629	.877	1.223	1.705	2.377	.....	.....
	Difference	— .038	+ .014	+ .140	.....	— .109	— .047	+ .032	0.095	1.39
Fifth	Observed mean	.286	.465	.769	1.114	.....	1.658	2.409	.....	.....
	Calculated mean	.337	.472	.662	.928	1.30	1.823	2.555	.....	.....
	Difference	— .051	— .007	+ .107	+ .186	.....	— .165	— .146	0.156	1.40
Sixth	Observed mean	.286	.465	.769	1.114	1.658	.....	2.409	.....	.....
	Calculated mean	.335	.480	.689	.989	1.420	2.037	2.923	.....	.....
	Difference	— .049	— .015	+ .080	+ .125	+ .238	.....	— .514	0.294	1.44

estimated head width for the given instar (X), log a is the first term, and log b is the slope of the line, or the logarithm of the desired growth ratio. For the purpose of calculation they then assumed that they had overlooked the second instar, the observed second instar then became the third, the observed third the fourth, and so on. The method of least squares was then applied and the progression so calculated was compared with their original calculated progression and a line of much better fit was obtained. Gaines and Campbell were certain that they had not missed an instar in their observations and decided that the application of Dyar's rule by the method of least squares did not corroborate the number of instars observed by them.

The values herein reported for the head sizes of the southern armyworm were treated in a similar manner. The lines of best fit were also calculated when each of the six instars was assumed to have been overlooked. The assumption that the first instar had been overlooked before any molts were observed is not included in Table III since all deviations were found to be exactly the same as when no instar was assumed to have been overlooked. In the unlikely case that the first molt had been completely overlooked this statistical procedure would offer no help in the detection of the oversight. As may be seen in the table the standard error of estimate, as calculated from observed deviations, for the case of not having overlooked any instar is 0.066 mm. When having assumed the omission of the second instar this figure is smaller but not significantly so whereas all the others are increasingly larger. The results of these calculations are shown in Table III and the graph on semi-log paper (fig. 2).

When the standard errors were calculated from logarithms and expressed as percentages the values were 5.8, 8.9, 7.5, 13.5, 15.8, and 16.6 This method represents the variance that is minimized by the process used. From these figures it may be concluded that the smallest relative standard error of estimate is associated with the series in which no instar was assumed to be missing and that the other errors taken in turn belong to correpsonding series in which it is assumed that successive instars have been overlooked.

In this study well over 2,000 larvae were measured. These larvae were taken from the cages over a period of 8 months.

The plot of the observed mean widths does not show a haphazard deviation, but a rather sharp break occurs in the curve at the third instar. A similar break at the third instar occurs in Gaines' and Campbell's plot of the mean width of the head of the corn earworm (*Heliothis armigera* (Hbh.)). The growth ratios of the late instars of both insects are considerably smaller than those of the earlier ones and possibly may correspond to some definite but as yet unknown change in the physiological state of the insects.

SUMMARY AND CONCLUSIONS

Measurements of the head-capsule sizes of over 2,000 larvae of all stages of the southern armyworm (*Prodenia eridania*) were made and were found to vary between 0.24 and 2.99 mm.

The larvae were grouped according to size of the head capsule to determine the frequency distribution. The larvae fell in six well defined groups corresponding to six instars. The mean ±1 standard deviation in millimeters for the first instar was 0.29±0.016; for the second, 0.47±0.037; for the third, 0.77±0.066; for the fourth, 1.11±0.083; for the fifth, 1.66±0.148; and for the sixth, 2.41±0.171.

The means were plotted logarithmically against the number of the instar, and the straight line of best fit was calculated by the method of least squares. From the data it was concluded that growth ratios tend to fall in a geometric progression, and that with this species there are only six instars. Results tend to throw doubt on the usefulness of Dyar's rule to detect missing instars.

A sharp break in the plot of the mean head capsule widths occurred at the third instar, the points apparently following regular progressions above and below this break. This break may correspond to a definite change in the physiological state of the insect.

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CHECKLIST OF THE COLEOPTEROUS INSECTS OF MEXICO, CENTRAL AMERICA, THE WEST INDIES AND SOUTH AMERICA. Part 1. Compiled by RICHARD E. BLACKWELDER. U. S. Nat. Mus. Bull. 185; 188 pages. 1944. For sale by Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price $0.35.

This first part of a list of Coleoptera south of the United States is the beginning of a series of lists planned by the Smithsonian Institution and the U. S. National Museum. The present part covers about thirty of the one hundred and twenty families of Coleoptera to be covered. It follows the Böving and Craighead list in "Synopsis of Larval Coleoptera," 1931, which arrangement was approved by the Peyerimhoff classification of 1933.

The Preface in English is repeated in Portuguese, in Spanish and in French. Lack of space apparently prevented the repetition of it in German for the many savants using that language in South America. We hope the small type used does not restrict its use to the younger men with good eyes.—C. H. K.

BIOLOGY OF IXODES MURIS BISHOPP AND SMITH (IXODIDAE)[1]

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Ixodes muris was described in 1937 by Bishopp and Smith[2] from larvae, nymphs, males, and females collected in Massachusetts. The hosts reported in this paper were the jumping mouse, the meadow mouse, the white-footed mouse, the Norway rat, the short-tailed shrew, and the muskrat. The localities from which collections were made were Cape Cod and the islands of Martha's Vineyard and Nantucket. There have been no subsequent publications on this species, and the biology was unknown at the time this study was started.

No common name has as yet been given to this species, but it seems that "the mouse tick" would be appropriate, as its normal hosts in all stages are the various species of mice and rats. This name is accordingly proposed for it.

Hosts and Distribution.—During the course of this study the following new host records have been obtained: dog, Edgartown, Mass., April 22, 1938, 1 female; long-tailed shrew, Edgartown, Mass., May 11, 1939, 8 larvae, 2 nymphs; cotton-tail rabbit, Oak Bluffs, Mass., October 11, 1938, 1 female; cotton-tail rabbit, Edgartown, Mass., April 27, 1940, 1 female; cotton-tail rabbit, Edgartown, Mass., June 14, 1940, 3 larvae. Additional records have been obtained from all hosts listed by Bishopp and Smith[2]. The most important host by far is the meadow mouse, because of its numbers, wide distribution, and susceptibility. Only the white-footed mouse rivals it in the first two respects. Whereas 864 larvae, 346 nymphs, and 63 females were found on 2,553 meadow mice, only 57 larvae, 26 nymphs, and 9 females were found on 714 white-footed mice captured at the same times and places.

An additional distribution record was obtained when two larvae were found on a meadow mouse captured at Melvin Village, N. H., June 28, 1940.

Methods of Study.—Experimental studies on the biology of the mouse tick were started at Vineyard Haven, Mass., in March 1938, using specimens of all stages collected in nature or reared in the laboratory. Records on molting of engorged larvae and nymphs and on preovipo-

[1]A portion of a thesis submitted to the Graduate Council of the George Washington University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2]Bishopp, F. C., and C. N. Smith, 1937. A New Species of *Ixodes* from Massachusetts. Proc. Ent. Soc. Wash., 39: 133–138.

sition, oviposition, and incubation of eggs from engorged females were obtained under outdoor conditions from ticks kept in rearing tubes and under incubator or room conditions from ticks kept in rearing tubes or in pill boxes set on moist sand. Records on the longevity of all stages under all conditions were obtained from ticks kept in rearing tubes. The rearing tubes were prepared from test tubes of soft glass 6 inches long and ¾ inch wide. The glass bottoms were removed, and a new bottom was made by tamping in a moist mixture of clay loam and sand. This mixture conducts water readily, is firm, and will not draw away from the sides of the tube if drying occurs. The tubes were kept in pans of moist sand indoors and in the soil outdoors. Light cloth tops confined the ticks in the tubes but gave good ventilation and permitted rapid evaporation of excess moisture after rains.

In obtaining the outdoor records the tubes were kept under two conditions so that the possibility of using abnormal records might be reduced. One lot of tubes was simply set in the soil to a depth of 2 inches, so that they were exposed to direct sunlight and rainfall as well as to all variations of temperature, humidity, and air circulation. These are referred to in subsequent tables as being "outdoors uncovered." The other lot of tubes was set in the soil under crates with roofing paper tops and sides of wood strips and screening, so that they were sheltered from direct rainfall and sunlight, but exposed to all variations of temperature, humidity, and air circulation. These are referred to as being in the "outdoor breeding cage." As will be shown later, no very great differences were noted between the records from the two locations, an indication that those from both were probably about normal.

All stages were engorged on meadow mice or other rodents confined in wire cages over pans of water, from which the ticks which had completed feeding and dropped were collected daily.

Records on seasonal abundance were based on collections of ticks from mice taken in nature. As ticks begin to leave the host shortly after its death, it was necessary to capture the animals alive rather than use traps that killed them, in order to obtain more reliable data on complete infestation. Box-type traps were used successfully. At first the mice caught in this way were etherized and the ticks removed, but later they were kept in cages over moats to permit the ticks to engorge and drop, as in the case of experimentally infested animals.

Oviposition.—The daily oviposition records of 7 engorged females and a description of them are presented in Tables I and II. It will be noted that the smallest total number of eggs deposited by a female was 135 and the largest 1,380. The average number of eggs deposited per female was 656, a very small number in comparison with those produced by other members of this family. The females required 7 to 25 days to deposit all their eggs, laying as many as 165 in a single day. Oviposition was influenced to some extent by the temperature, the most eggs being deposited on warm days. Two females died the day after oviposition was completed, whereas 5 lived for 1 to 13 additional days. One female, not shown in the table, lived for more than a month.

TABLE I

Description of Females Used for Oviposition Records

Female No.	Date of Dropping	Location of Female	Size of Female, mm.
	1939		
1	Apr. 10	Outdoor breeding cage	7.3 x 5.4 x 4.2
2	May 1	do	7.9 x 5.7 x 4.6
3	29	Outdoors uncovered	7.2 x 5.0 x 4.5
4	July 11	Outdoor breeding cage	7.1 x 5.4 x 4.9
5	19	Outdoors uncovered	7.8 x 5.9 x 5.0
6	25	do	8.2 x 6.0 x 5.5
	1940		
7	June 3	do	7.0 x 5.0 x 4.6

TABLE II

Daily Oviposition Record of Seven Females

Day After Dropping	Number of Eggs Laid by Female No.							Day After Dropping	Number of Eggs Laid by Female No.						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
8	....	....	....	....	24	22	....	37	....	*	....	....	....	....	*
9	....	....	....	75	94	34	....	38	10	....	*	....	....	....	....
10	....	....	....	88	....	81	....	39	15	....	....	....	....	....	....
								40	....	....	....	....	....	....	....
11	....	....	....	65	99	25	....								
12	....	....	....	149	63	108	....	41	....	....	....	....	....	....	....
13	....	....	....	66	113	149	....	42	16	....	....	....	....	....	....
14	....	....	28	165	35	18	....	43	29	....	....	*	....	....	....
15	....	....	70	123	*	13	14	44	30	....	....	....	....	....	....
16	....	....	26	111	....	*	49	45	43	....	....	....	....	....	....
17	....	....	29	91	....	....	32	46	54	....	....	....	....	....	....
18	....	....	37	117	....	....	....	47	49	....	....	....	....	....	....
19	....	....	39	69	....	....	41	48	88	....	....	....	....	....	....
20	....	....	52	52	....	....	42	49	91	....	....	....	....	....	....
								50	68	....	....	....	....	....	....
21	....	....	30	74	....	....	36								
22	....	....	62	45	....	....	29	51	81	....	....	....	....	....	....
23	....	....	81	30	....	....	29	52	27	....	....	....	....	....	....
24	....	....	47	25	....	....	40	53	38	....	....	....	....	....	....
25	....	....	46	16	....	....	31	54	24	....	....	....	....	....	....
26	....	....	45	....	....	....	28	55	31	....	....	....	....	....	....
27	....	6	54	12	....	....	10	56	40	....	....	....	....	....	....
28	....	39	24	....	....	....	41	57	30	....	....	....	....	....	....
29	....	47	23	....	....	....	23	58	19	....	....	....	....	....	....
30	....	....	41	7	....	....	19	59	27	....	....	....	....	....	....
								60	12	....	....	....	....	....	....
31	....	2	37	....	....	....	15								
32	....	24	29	....	....	....	3	61	8	....	....	....	....	....	....
33	....	17	35	....	....	....	9	62	3	....	....	....	....	....	....
34	....	....	19	....	....	....	13	63	....	....	....	....	....	....	....
35	....	....	3	....	....	....	1	64	1	....	....	....	....	....	....
36	....	....	3	....	....	....	....								
								Total	833	135	860	1380	428	450	505

*Female died.

TABLE III

PREOVIPOSITION, INCUBATION, AND LARVAL LONGEVITY

Date Female Dropped	Location of Female	Date of First Oviposition	Date of First Hatch	Date Some Larvae Were Last Seen Alive	Date All Larvae Were Dead	Pre-oviposition Period, Days	Incubation Period, Days	Larval Longevity, Days
1938		1938	1938					
May 7	Incubator	May 20	June 19	July 9, 1938*	.....	13	30	.....
11	do	19	19	July 26, 1938*	.....	8	31	.....
June 4	do	June 11	July 9	do	.....	7	28	.....
July 19	Heated room	July 19–26	Aug. 29	June 16, 1939	July 26, 1939	1–7	34–41	291–331
Oct. 19	Incubator	Oct. 28	Nov. 19	Apr. 11, 1939	May 20, 1939	9	21	144–183
19	do	25	18	May 20, 1939	June 16, 1939	6	23	184–211
1939		1939	1939					
Apr. 10	Outdoors uncovered	May 9–12	July 8	Aug. 24, 1939*	.....	29–32	57–60	.....
11	do	9–12	7	May 10, 1940	June 14, 1940	28–31	56–59	308–343
16	Outdoor breeding cage	21	12	Oct. 15, 1940	Nov. 20, 1940	35	52	461–497
May 12	Outdoors uncovered	31	15	Dec. 18, 1939*	.....	19	45	.....
12	do	June 6	21	do	.....	25	45	.....
16	do	May 30	14	June 14, 1940	July 18, 1940	14	45	336–370
19	do	June 2	16	July 18, 1940	Aug. 15, 1940	14	44	368–396
25	Outdoor breeding cage	7	24	Aug. 15, 1940	Sept. 18, 1940	13	47	388–422
June 16	Outdoors uncovered	June 16–July 2	Aug. 6	June 11, 1940*	.....	1–16	35–51	.....
July 11	Outdoor breeding cage	July 20	24	Oct. 15, 1940	Nov. 20, 1940	9	35	418–454
18	Outdoors uncovered	27	27	Sept. 18, 1940	Oct. 15, 1940	9	31	388–446
19	do	27	28	June 14, 1940	July 18, 1940	8	32	291–325
19	do	27	30	Sept. 18, 1940	Oct. 15, 1940	8	34	385–446
25	do	Aug. 2	Sept. 7	June 14, 1940	July 18, 1940	8	36	281–315
25	Outdoor breeding cage	1	4	Nov. 20, 1940	Jan. 9, 1941	7	34	443–493
26	Outdoors uncovered	1	13	July 18, 1940	Aug. 15, 1940	6	43	309–337
Aug. 1	Outdoor breeding cage	10	18	Nov. 20, 1940	Jan. 9, 1941	9	39	429–479
1	do	15	18	do	do	14	34	429–479
1	Outdoors uncovered	8	12	Oct. 15, 1940	Nov. 20, 1940	7	35	399–435
1	do	10	13	do.	do	9	34	398–434
		1940	1940					
16	Outdoor breeding cage	May 10–June 3	July 17	June 17, 1941	July 15, 1941	268–292	44–68	335–363
20	do	10–June 3	16	Sept. 15, 1941	Oct. 6, 1941	264–288	43–67	426–447
20	Outdoors uncovered	April 29–May 10	15	Apr. 12, 1941	May 22, 1941	253–264	66–77	271–311
25	do	29–May 10	8–14	Jan. 9, 1941	Mar. 14, 1941	248–259	59–76	179–249
Sept. 14	do	29–May 10	8–14	Apr. 12, 1941	May 22, 1941	228–239	59–76	272–318
15	do	May 10–June 3	8–14	Nov. 20, 1940	Jan. 9, 1941	238–262	35–65	129–185
16	Outdoor breeding cage	10–June 3	20	June 17, 1941	July 15, 1941	237–261	47–71	332–360
1940								
Mar. 27	Outdoors uncovered	10–June 14	Aug. 2	July 15, 1941	Aug. 14, 1941	44–79	49–83	347–377
Apr. 9	Outdoor breeding cage	10–June 3	July 20	do	do	31–55	47–71	360–390
May 11	Outdoors uncovered	11–June 3	20	July 31, 1940*	.....	1–23	47–70	.....
13	do	13–June 3	22	Sept. 13, 1940*	.....	1–21	49–70	.....
June 1	Outdoor breeding cage	June 14	Aug. 1	Aug. 14, 1941	Sept. 15, 1941	13	48	378–410
16	Outdoors uncovered	24–July 2	12	do	do	8–16	41–49	367–399
16	Outdoor breeding cage	24–July 2	12	do	do	8–16	41–49	367–399
16	Outdoors uncovered	24–July 2	12	July 15, 1941	Aug. 14, 1941	8–16	41–49	337–367
21	do	July 6	14	Aug. 14, 1941	Sept. 15, 1941	15	39	365–397
July 24	do	Aug. 1	Sept. 17	do	do	8	47	331–363

* Engorged.

Preoviposition.—Preoviposition records on ticks held under outdoor conditions, in an incubator at 80° F. and in a heated room, are presented in Table III. In the incubator the preoviposition period ranged from 6 to 13 days and under outdoor conditions from 6 to more than 268 days, as females which completed engorgment between the middle of August and the middle of September did not begin oviposition until the following spring. Since females are active in nature until the end of September, it must be assumed that this wide variation in the preoviposition period is a frequent and normal occurrence.

Incubation of Eggs.—The incubation period ranged from 21 to 31 days in the incubator and from 31 to between 66 and 77 days outdoors (Table III). It will be noted that oviposition beginning as late as August 15, 1939, from females dropping on August 1, resulted in hatching the same fall, beginning September 18. This hatching was completed by October 13. As females which dropped only 2 weeks later, August 16, did not oviposit until the next spring, no egg masses would be subjected to the winter. This would seem to be a definite provision of the developmental cycle to assure that a susceptible stage, the egg, would not be destroyed by the onset of winter. Only one batch of eggs was actually exposed over winter, that from the female shown to have dropped July 26, 1939. Hatching began September 13, but whereas the four later lots all completed hatching during September and October, only seven eggs of this lot hatched during the fall, although the other eggs all showed white viable spots. None of these eggs hatched the next spring, but as they had developed abnormally in September and October it cannot definitely be said that they were killed by the winter.

The earliest hatching in 1939 occurred on July 7, from eggs laid by a female dropped April 11, and only a week later, July 14, there was hatching from eggs laid by a female that had not dropped until May 16. In 1940 eggs from overwintered females began hatching between July 8 and July 14, and eggs from females engorged the same spring, April 9 and May 11, began hatching July 20.

Larval Longevity.—The larvae are able to survive exposure to the winter satisfactorily and engorge normally the following spring, as shown in Table III. These were not cases of only a few larvae surviving, but the majority of the individuals in the lots came through in good condition, clustered in dense masses on the walls of the tubes. In April and May these clusters began to break up, the larvae crawling about individually. It will be noted that the longevity of lots kept outdoors ranged from about 130 to 490 days. Although no lot survived two winters, several lots lived through two complete seasons of larval activity.

Larval Engorgement.—The larvae were easily induced to feed on meadow mice, and records on engorgement were obtained without difficulty, as many as 649 engorging at one time on one mouse. Records on 4,487 larvae are listed in Table IV. Eighteen completed engorgement in 2 days, and 1 required 9 days, with the largest number (2,758) becoming fully engorged in 4 days. The average for the entire group was 3.9 days. There was no tendency to drop at any particular time of day, as in the case of some species. In some lots the majority dropped during

daylight hours and in others at night. Dropping simply built up to a single peak and fell away rapidly, the peak sometimes occurring at night and sometimes in the daytime. Larvae engorged satisfactorily on a muskrat, but not on a cotton-tail rabbit, although they have been found on both these hosts in nature. The average dimensions of 20 fully engorged larvae were 1.33 mm. from the tip of the hypostome to the

TABLE IV

SEASONAL ENGORGEMENT OF LARVAE

Date Larvae Were Put On Host	Number of Larvae That Dropped Engorged on Specified Day Following Attachment								
	2	3	4	5	6	7	8	9	Total
1938									
July 9		28	182	27	4				241
9		4	190	83	10	1	2		290
26		43	515	78	12	1			649
26		81	423	37	1				542
26		90	201	12	1				304
Sept. 8		25	430	127	4				586
19		76	72	15					163
Dec. 6		20	32						52
16		161	104	17	1				283
1939									
Apr. 19			3	3		1			7
26		5	27	12	3			1	48
May 10		2		4					6
July 13		34	2	2					38
20		5	18	11	3				37
Aug. 10		21	108	6	1				136
14		293	285	23					601
24		65	48	3					116
Oct. 13			1	10	2				13
24		6							6
Nov. 10		6	1	5					12
10		3	2	1					6
Dec. 1			4	2	2				8
1940									
June 11		3	16	9	4				32
15			4	2	3				9
July 30			53	14	5		1		73
Aug. 27	18	167	37	4	2	1			229
Total	18	1,138	2,758	507	58	4	3	1	4,487

posterior extremity, 0.91 mm. across the body at the spiracles, and 0.69 mm. dorsoventrally at the thickest point. The maximum dimensions observed were 1.38 by 0.96 by 0.69 mm. and the minimum dimensions 1.29 by 0.87 by 0.66 mm.

Larval Molting.—Records on the molting of 533 engorged larvae, which were kept at a constant temperature of 80° F., are shown in Table V. The time required for molting ranged from 19 to 33 days.

In the case of individuals kept under outdoor conditions the time required was extended and the variation greatly increased, as shown by the records presented in Table VI. In the lots which became engorged and were placed outdoors at intervals from April to August, the molting period was as short as 26 days and as long as 79 days. It was of course greatly influenced by the temperature, but even in single lots the time required ranged from 31 to 46 days. In the case of larvae completing engorgement as late as September 15, the engorged larvae pass the winter satisfactorily and molt the following summer, the molting period in this case being extended to as much as 296 days. As larvae are commonly engorging at this time in nature, hibernation in the engorged as well as the unfed state must be considered a normal occurrence. As in the case of the incubation of eggs, the molting of larvae engorged

TABLE V

LARVAL MOLTING AT A CONTROLLED TEMPERATURE OF 80° F., 1938

Date of Dropping	No. of Larvae	Number That Molted on Specified Day After Dropping															
		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Total
Apr. 29	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1
May 7	1	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	1
July 2	89	....	....	....	....	....	2	17	20	32	10	6	....	....	....	....	87
2	364	....	63	101	118	65	8	3	1	2	....	....	....	....	....	....	361
3	42	1	7	11	12	7	2	....	....	....	....	....	....	....	....	....	40
4	12	....	....	....	1	....	....	1	....	....	....	....	....	....	....	....	2
12	28	....	....	1	6	6	10	1	2	....	....	....	....	....	....	....	26
14	27	....	2	3	3	1	....	....	....	....	....	....	....	....	....	....	9
12	4	....	....	....	....	3	....	....	....	....	....	....	....	....	....	....	3
15	10	....	....	....	1	2	....	....	....	....	....	....	....	....	....	....	3
Total	579	1	72	116	141	84	22	22	23	34	10	6	0	1	0	1	533

over a period of two months in April and May began in a period of about a week in early July. In 1939 molting began on July 2 from larvae engorged the same spring, but in 1940 only overwintered larvae molted before July 15.

Nymphal Longevity.—Records on nymphal longevity are presented in Table VI. The unengorged nymphs, like the unengorged larvae, survive the winter without injury, the majority living through the entire following summer. One lot engorged satisfactorily when 268 days old and another when 383 days old. Some lots died about a year after molting, whereas one lot lived for more than 3 years and a number lived 2 years.

Nymphal Engorgement.—The nymphs engorged fairly readily on meadow mice under experimental conditions, as many as 95 engorging on a single mouse at one time. Records on engorgement for 714 nymphs are given in Table VII. One individual completed engorgement in 2 days, the majority required 3 days, and other individuals dropped after 4 to 8 days. The average period for the group was 3.7 days. Nymphs

TABLE VI

LARVAL MOLTING AND NYMPHAL LONGEVITY

Date of Dropping	Number of Larvae	Location	Date First Larva Molted	Date Last Larva Molted	Date Last Nymph Died	Molting Period, Days	Nymphal Longevity, Days
1938			1938	1938			
July 29	90	Outdoor breeding cage	Aug. 1–31	Aug. 1–31	Nov. 20, 1940–Jan. 9, 1941		781–861
31	127	do	1–31	1–31	Aug. 14–Sept. 15, 1941		1,079–1,141
Sept. 13	50	do	Oct. 14-Nov. 17	Oct. 14-Nov. 17	Sept. 18–Oct. 15, 1940		672–732
1939			1939	1939			
Apr. 16	1	Outdoors uncovered	July 2	July 2	Sept. 18–Oct. 15, 1940	77	444–471
27	1	Outdoor breeding cage	7	7	do	71	439–466
30	27	Outdoors uncovered	5	18	Nov. 20, 1940–Jan. 9, 1941	65–79	491–554
May 1	12	Outdoor breeding cage	13	18	July 18–Aug. 15, 1940	73–78	366–394
12	3	Outdoors uncovered	5	9	Nov. 20, 1940–Jan. 9, 1941	54–58	500–554
29	2	do	11	16	do	43–48	493–548
July 16	34	Outdoor breeding cage	Aug. 15	Aug. 18	Aug. 14–Sept. 15, 1941	30–33	727–762
20	2	Outdoors uncovered	23	23	July 18–Aug. 15, 1940	34	330–358
22	9	do	20	26	Sept. 18–Oct. 15, 1940	29–35	389–422
23	12	do	18	26	Aug. 14–Sept. 15, 1941	26–34	719–759
24	26	Outdoor breeding cage	20	23	Nov. 5–Dec. 9, 1941	27–30	805–842
25	11	Outdoors uncovered	20	25	Aug. 15–Sept. 18, 1940	26–31	356–395
Aug. 1	4	do	29	30	do	28–29	351–386
3	5	Outdoor breeding cage	30	Sept. 2	Oct. 6–Nov. 11, 1941	27–30	765–798
14	108	Outdoors uncovered	Sept. 11	17	June 11, 1940*	28–34	*268
13	21	Outdoor breeding cage	12	18	Sept. 15–Oct. 6, 1941	30–36	728–755
17	139	do	17	27	July 15–Aug. 14, 1941	31–41	657–697
17	154	Outdoors uncovered	17	Oct. 2	June 17–July 15, 1941	31–46	624–667
18	285	Outdoor breeding cage	18	1	Oct. 18, 1940*	31–44	*383
19	23	Outdoors uncovered	22	Sept. 30	Jan. 9–Mar. 14, 1941	34–42	467–539
27	65	do	30	Oct. 6	July 15–Aug. 14, 1941	34–40	648–684
28	48	Outdoor breeding cage	Oct. 1	7	Jan. 19–Feb. 18, 1942	34–40	835–871†
			1940	1940			
Sept. 15	21	Outdoors uncovered		July 3	July 15–Aug. 14, 1941	–296	
Oct. 27	6	do	June 24-July 3	6	Sept. 18–Oct. 15, 1940	–253	74–113
Nov. 15	6	Outdoor breeding cage	July 8		Nov. 5–Dec. 9, 1941	236–	
1940							
May 11	1	Outdoors uncovered	15	July 15	Nov. 20, 1940–Jan. 9, 1941	65	128–178
June 15	16	Outdoor breeding cage	29	Aug. 1	†	44–47	†
16	9	Outdoors uncovered	28	5	†	42–50	†

* Engorged.

† Alive May 15, 1942.

were engorged satisfactorily on a muskrat and a cotton-tail rabbit. There was no evidence of a tendency to drop at any particular time of day. The average dimensions of 20 fully engorged nymphs measured in the same manner as the larvae were 2.42 by 1.61 by 1.27 mm. The maximum dimensions observed were 2.70 by 1.71 by 1.44 mm. and the minimum dimensions 2.25 by 1.59 by 1.17 mm.

TABLE VII

SEASONAL ENGORGEMENT OF NYMPHS

Date Nymphs Were Put on Host	Number of Nymphs	Number That Dropped Engorged on Specified Day Following Attachment							
		2	3	4	5	6	7	8	Total
1938									
July 26	35		12	9					21
Aug. 30	200		14	14	2	3			33
Sept. 12	35		1						1
12	105		41	7	2				50
17	430		3	9	8	1	3	1	25
15	200		11	12	3				26
16	70		13	8	4				25
19	90		16	9	4				29
Oct. 10	150		45	10	1				56
10	50		19	7	1				27
26	120			5	4				9
Nov. 4	90		1						1
21	50		2	5	3				10
Dec. 16	200		48	43	4				95
23	150		36	24	7	8	1		76
1939									
Jan. 20	200		46	16	10				72
20	107		16		3				19
20	117		22	4	2	3	1		32
Apr. 11	48	1	9	2		1			13
17	50		15	3					18
May 2	60		1	7	20	1	2		31
10	38		1	16	2				19
20	40		1	4	3				8
1940									
June 11	95		1	2					3
15	15		6	6					12
15	25			3					3
Total	2,770	1	380	225	83	17	7	1	714

Nymphal Molting.—Typical records on nymphal molting are presented in Table VIII. Among nymphs kept at a constant temperature of 80° F. molting required from 31 to 48 days for nymphs producing males and from 35 to 48 days for nymphs producing females. In the case of nymphs kept outdoors under natural conditions the molting period varied greatly. Among lots exposed during the high temperatures of July and August it was reduced to as little as 25 days, whereas among those exposed during the colder weather of April it was extended to as

TABLE VIII

Nymphal Molting and Adult Longevity

Date of Dropping	Number of Nymphs	Location	Date First Nymph Molted	Date Last Nymph Molted	Date Last Adult Died	Molting Period, Days	Adult Longevity, Days
1938			1938	1938			
Mar. 28	2	Incubator	May 7	May 8		40–41	
Apr. 28	3	do	June 4	June 11		37–44	
29	6	do	May 30	16		31–48	
May 1	4	do	June 11	18		41–48	
2	2	do	10	10		39	
6	6	do	9	16		34–41	
7	2	do	12	16		36–40	
8	2	do	9	14		32–37	
July 25	5	Outdoor breeding cage	Aug. 1–31	Aug. 1–31	Aug. 15–Sept. 18, 1940		715–779
Sept. 15	10	do	Oct.14-Nov.17		June 14–July 18, 1940		
			1939	1939			
23	9	Outdoors uncovered	July 7	July 24	Oct. 15–Nov. 20, 1940	287–304	449–502
1939							
Apr. 13	3	do	9	11	Aug. 14–Sept. 15, 1941	87–89	765–799
14	9	Outdoor breeding cage	15	Aug. 2	*	92–110	*
17	5	Outdoors uncovered	10	July 17	Aug. 14–Sept. 15, 1941	84–90	759–798
20	15	Outdoor breeding cage	27	Aug. 7	Sept. 18–Oct. 15, 1940	98–109	408–446
26	5	Outdoors uncovered	7	July 27	Nov. 20, 1940–Jan. 9, 1941	72–92	482–552
27	7	Outdoor breeding cage	10	29	Jan. 9–Mar. 14, 1941	74–93	530–613
May 7	10	do	26	Aug. 8	May 22–June 17, 1941	80–94	653–692
7	10	Outdoors uncovered	25	14	June 11, 1940†	79–99	†302
12	3	do	11	July 19	April 12–May 22, 1941	60–68	633–681
19	3	Outdoor breeding cage	26	29	Jan. 9–Mar. 14, 1941	68–71	530–597
24	4	Outdoors uncovered	5	20	Jan. 9–Mar. 14, 1941	42–57	539–618
25	3	Outdoor breeding cage	10	16	Dec. 9, 1941–Jan. 19, 1942	46–52	877–924
June 16	1	Outdoors uncovered	Aug. 18	Aug. 18	Nov. 20, 1940–Jan. 9, 1941	63	460–510
July 13	1	Outdoor breeding cage	14	14	*	32	*
14	2	Outdoors uncovered	17	17	Sept. 22, 1939–Feb. 7, 1940	34	36–174
15	2	Outdoor breeding cage	15	16	*	31–32	*
19	1	do	23	23	April 12–May 22, 1941	35	598–638
20	3	Outdoors uncovered	16	21	Aug. 15–Sept. 18, 1940	27–32	360–399
21	2	Outdoor breeding cage	19	Sept. 2	Aug. 14–Sept. 15, 1941	29–43	712–758
Aug. 3	3	Outdoors uncovered	28	14	June 17–July 15, 1941	25–42	642–687
24	2	do	Oct. 1	Oct. 5	Jan. 19–Feb. 18, 1942	38–42	837–871
			1940	1940			
Sept. 14	1	do	July 22	July 22	*	312	*
15	2	do	23	25	Feb. 18–Mar. 17, 1942	312–314	573–602
16	1	Outdoor breeding cage	Aug. 1	Aug. 1	*	320	*
1940							
May 11	1	Outdoors uncovered	July 26	July 26	*	76	*
June 15	2	Outdoor breeding cage	29	Aug. 1	Sept. 18–Oct. 15, 1940	44–47	48–78
18	6	Outdoors uncovered	28	6	Aug. 14–Sept. 15, 1941	40–49	373–414
19	9	Outdoor breeding cage	Aug. 2	14	*	44–56	*

* Alive May 15, 1942. †Engorged.

much as 110 days. Four nymphs that dropped in September, 1939, survived the winter in the engorged state and molted the following summer, giving molting periods of 312, 312, 314, and 320 days. In 1938, when the fall months were warmer than in 1939, 10 nymphs that dropped September 15 began molting the same fall, whereas 9 that dropped September 23 did not molt until the following summer, after 287 to 304 days. Since nymphs are active in nature at this time, it is evident that hibernation in the engorged condition is a normal occurrence, as in the case of females and larvae.

The molting period was somewhat shorter in the case of nymphs producing males than in the case of nymphs producing females when exposed to identical conditions. Of the 17 lots producing adults of both sexes, males molted first in 15 lots, and all males molted before any females in 12 lots. There was also a significant difference in the proportion of adults of each sex produced. Of the 130 nymphs under discussion 77 produced males (59.2 per cent) and 53 molted to females.

The earliest molting under outdoor conditions in 1939 was on July 5, from nymphs dropping on May 24, with overwintered nymphs molting shortly thereafter. Molting continued until October 5. The earliest molting in 1940 occurred on July 22, from overwintered nymphs, but no early spring records had been started.

Adult Longevity.—Records on adult longevity are shown in Table VIII. Both sexes survived the winter readily, and females engorged and oviposited when almost a year old. Practically all lots lived through parts of two seasons of activity, and many lots lived through parts of three seasons of activity, showing a maximum longevity of 877 to 924 days.

Mating Habits.—The adults of the mouse tick do not mate on the host, but on the ground before the females have attached. In rearing tubes mating was often observed less than 24 hours after the females had molted. As males had usually molted some days before the females appeared, the shortest possible interval between molting and mating is not known for that sex. Sometimes mating pairs parted within a few hours, but sometimes they remained paired for days. One pair was observed to mate in September 1939 and again in May 1940. The males never feed and, except for the one specimen reported in the original description of this species, have never been found on a mouse or other animal. Even when confined on mice, males consistently refused to attach.

When females had been kept separated from males, so that there had been no opportunity for them to mate, they refused to attach to mice even when confined on them, but females which had mated attached and engorged readily.

Adult Engorgement.—Records on engorgement for 55 females are shown in Table IX. Two individuals completed feeding in 4 days and one individual required 8 days, whereas all the others dropped after 5 or 6 days. The average period was 5.4 days. Although females have been found on cotton-tail rabbits in nature, one attempt to engorge them experimentally on this host was unsuccessful. The average dimensions of 47 fully engorged females, measured in the same manner

as the larvae, were 7.2 by 5.2 by 4.3 mm. The largest female observed measured 8.2 by 6.0 by 5.5 mm., and the smallest 5.9 by 4.3 by 3.9 mm.

Seasonal Activity.—Studies on the seasonal activity of the various stages in connection with the developmental cycle were based on data of two types. Engorged ticks in all stages were exposed to outdoor conditions using the methods previously described. As specimens were started at intervals throughout the season of activity, it is possible to

TABLE IX

SEASONAL ENGORGEMENT OF FEMALES

Date Females Were Put on Host	Number of Females	Number That Dropped Engorged on Specified Day Following Attachment					
		4	5	6	7	8	Total
1938							
May 29	2			1			1
July 9	5			2			2
Sept. 19	4		2				2
Oct. 14	9		3	1			4
26	8		2				2
Nov. 4	6		1				1
Dec. 9	8		3				3
10	15		4	1		1	6
20	5			2			2
1939							
Mar. 17	9	1					1
Apr. 10	4	1	1				2
26	7		3				3
May 10	8		2	3			5
July 13	8			2			2
19	6			1			1
20	4			1			1
27	6		3				3
27	10		3				3
Aug. 10	7			2			2
14	10			2			2
Sept. 7	9			1			1
1940							
Mar. 21	3			2			2
June 11	3		3				3
July 19	1		1				1
Total	157	2	31	21	0	1	55

determine from these records exactly when hatching or molting would occur from ticks dropping in any part of the season. These records have been listed in the foregoing tables. Data of a second type were obtained by collecting all stages from wild mice captured in nature throughout the season of tick activity. As mentioned previously, about 2,500 mice were examined, collections being made every month from August 1937 to October 1941 at four localities and occasionally in a number of additional areas. The collections in one locality, typical of all, are presented in Table X. By a comparison of these two types

of records it should be possible to determine which developmental potentialities are normally realized.

Larval Activity.—It will be noted in Table X that in all three years, 1938, 1939, and 1940, larvae were scarce until July at Edgartown, the area where this species was most abundant. This might mean either that few larvae were in the area or that larvae were present in numbers but did not become active before July. However, it will be noted in Table III that the earliest hatching under outdoor conditions, from females that engorged at the beginning of their season of activity, occurred on July 7 in 1939 and on July 20 in 1940. About July 8, 1940, hatching began from eggs deposited by females that had dropped the

TABLE X

SEASONAL ABUNDANCE OF *Ixodes muris* AT EDGARTOWN, MASS., AS INDICATED BY THE TOTAL NUMBER OF TICKS TAKEN ON MICE, 40 MOUSE TRAPS HAVING BEEN SET ONCE EACH MONTH

Month	Number of Mice and Ticks Collected Each Month in Specified Year											
	Mice			Larval Ticks			Nymphal Ticks			Adult Ticks		
	1938	1939	1940	1938	1939	1940	1938	1939	1940	1938	1939	1940
Jan.	11	10	8	....	....	....	....	....	....	....	....	....
Feb.	8	8	10	....	....	....	....	....	....	....	....	....
Mar.	4	9	10	....	....	....	6	....	1	3	....	....
Apr.	5	9	7	....	1	....	1	15	....	....	1	....
May	14	7	12	....	....	1	6	2	3	2	....	2
June	14	9	21	....	....	....	....	8	2	....	1	2
July	21	10	19	14	3	23	4	1	7	....	....	....
Aug.	20	18	20	40	40	94	....	4	5	....	1	....
Sept.	26	22	19	23	52	31	....	3	2	....	4	....
Oct.	15	11	17	....	5	3	1	....	....	....	....	....
Nov.	11	14	26	....	....	3	....	....	....	....	....	....
Dec.	15	4	7	....	....	....	....	....	....	....	....	....

previous fall. Within 17 days after the earliest hatching, the eggs from all the females engorged throughout April and May began to hatch, and, within the same fortnight, hatching began among the eggs of all females engorged after August 15 of the preceding year. Therefore, a large number of eggs hatch immediately before the sudden July and August peak of larval abundance, an indication that the small number of ticks found previously, and the large number found later, are due to an absence of overwintering larvae and the midsummer hatching, respectively. Also the records for 1939 in Table III show that no hatching began after September 13 from females dropped August 1. Females dropped August 16 and later did not oviposit until the following spring. In the same year larvae were active until mid-October, giving the majority time to engorge the same fall and accounting for the small carry-over to the next spring.

By comparison of the two types of records one finds that in nature there is little larval activity before late July, as few flat larvae survive

the winter. As soon as hatching occurs, either from females engorged the same spring or from those dropped the previous fall, the newly hatched larvae become active, and activity continues until October or November, when the great majority of larvae have become engorged. The few larvae that do not have an opportunity to feed survive the winter readily and engorge the following spring. All the foregoing, of course, applies to areas in which mice are plentiful. If mice were scarce in an area, a larger proportion of larvae might fail to find hosts and survive from one season to the next.

The seasonal abundance in a second area, where the species was less numerous, was less regular but conformed in general with that just discussed, an indication that this behavior is typical of other areas as well.

Nymphal Activity.—It will be noted that in all years the seasonal abundance of nymphs in the Edgartown area was irregular, rising and falling several times. In order to interpret this fluctuation, one must consider the seasonal abundance of larvae and the records of larval molting under outdoor conditions (Table VI). In all years nymphs were very active at the beginning of the season. As the spring of 1938 was warmer than that of 1939 and the spring of 1940 colder than either, nymphs reached a peak of activity in March, April, and May of those years, respectively. As no molting occurred this early in the season from larvae dropped at any time, these nymphs evidently hibernated in that stage. The column of larval abundance shows that the majority of larvae drop in August and September. Larvae dropping in August would not molt until September or October, when few nymphs are active, an indication that the great majority would carry over to form this spring peak. Possibly some larvae engorged in July molt early enough to form a peak in August, as indicated in 1939, although this does not appear to have happened in 1938 or 1940. The larger number of larvae engorging in September may molt the same fall, as some did in 1938, or may survive the winter, as they did in 1939, molting the following July in time to cause the nymphal peak noted in that month.

The seasonal abundance of nymphs in a second area agrees in general with that in the first.

Adult Activity.—Adults occur in such small numbers that a listing of the seasonal abundance reveals little. They have been found on mice every month from March through September. Of collections from all areas, there were 27 in which only 1 female was taken, 7 in which 2 females were taken, 3 in which 3 females were taken, and 2 in which 4 were taken. As no nymphs molted before July in nature (Table VIII), some females obviously passed the winter in the adult stage, whereas others probably engorged the same summer in which they molted.

STUDIES ON TRIBOLIUM CONFUSUM DUVAL

III. ABNORMALITIES PRODUCED IN TRIBOLIUM CONFUSUM DUVAL BY EXPOSURE TO ACETIC AND HYDROCHLORIC ACIDS

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Roth and Howland (1941) found that various abnormalities could be produced in *Tribolium confusum* by subjecting different developmental stages of this beetle to both the vapors and crystals of the odoriferous substance given off by the adults. The most interesting deformities were obtained by direct application of the crystals to the leg region of last instar larvae. Affected larvae gave rise to adults which possessed abnormal legs. These varied from mere undifferentiated outgrowths to complete duplications and triplications of various parts. It was suggested at that time that these abnormalities may have resulted from a regeneration of the imaginal discs which were injured by the odoriferous substance. Duplications and triplications are supposedly not uncommon abnormalities resulting from regeneration. If these deformities are cases of regeneration due to injury, then it should be possible to injure the discs with other chemicals and so obtain similar monstrosities.

Although the original purpose of the following experiments was to determine if duplications and triplications could be obtained by the application of various chemicals to the leg region of larvae, various stages of *Tribolium* were also subjected to the vapors of acids to compare abnormalities, if any, with those produced with the vapors of the odoriferous substance.[2]

MATERIALS AND METHODS

Experimental and control animals were reared as described by Roth and Howland (1941). The developmental stages used were sifted from the flour when needed. All animals were reared at 29° C.

Various chemical agents were tried. These were chosen for no specific reason except that they were present in the laboratory and no doubt would be more or less injurious to the insect. They included M/100 KCN in spring water, 0.01% strychnine sulphate, acetone, glacial acetic acid, and HCl. From preliminary experiments it was

[1]This study was completed in the Department of Entomology, Ohio State University, Columbus, Ohio.

[2]Since this paper was written the odoriferous substance given off by *Tribolium* has been identified as ethylquinone (P. Alexander and D. H. R. Barton, Biochemical Journal Vol. 37: 463–465: 1943). The development and structure of the glands producing this substance has also been described (L. M. Roth, Ann. Ent. Soc. Amer., 36: 397–424: 1943).

found that the first three substances gave very few abnormalities while acetic and hydrochloric acids gave the greatest number and most drastic effects. Therefore the effects of these two acids were studied in some detail.

The chemicals were applied by means of a micropipette attached to an injection circuit similar to that on a Chambers micromanipulator. This was set up on a binocular dissecting microscope. A drop or drops of acid generally large enough to cover the leg region of a larva was applied to each experimental animal. Larvae were etherized during treatment (controls were etherized for the same length of time as experimentals).

Larvae were also treated with crystals of the odoriferous substance to check the previous results obtained. The technique described by Roth and Howland for collecting and applying the crystals was used in the present work.

Various stages of *Tribolium* were subjected to the vapors of concentrated hydrochloric and acetic acids. Preliminary experiments with the vapors of HCl showed that all stages (last instar, prepupae, and pupae) were killed with a five minute exposure and that after a two minute exposure, the percentage of mortality was high and consequently the percentage of abnormality low. Therefore the various stages were exposed to the vapors of acetic acid only. The apparatus described by Roth and Howland, for gassing, was used with a slight modification. A train of 14 vials (7 controls and 7 experimentals), $\frac{7}{8}''$ x $3\frac{3}{4}''$, was devised (see Roth and Howland, 1941, fig. 2).

After treatment all animals were placed in syracuse dishes and reared at 29° C. Adults were examined in alcohol, in a white porcelain evaporating dish, under a binocular dissecting microscope; thus any abnormalities were easily detected. Abnormal appendages were dissected away, dehydrated, cleared in xylol and mounted unstained in balsam. All drawings were outlined with the aid of camera lucida.

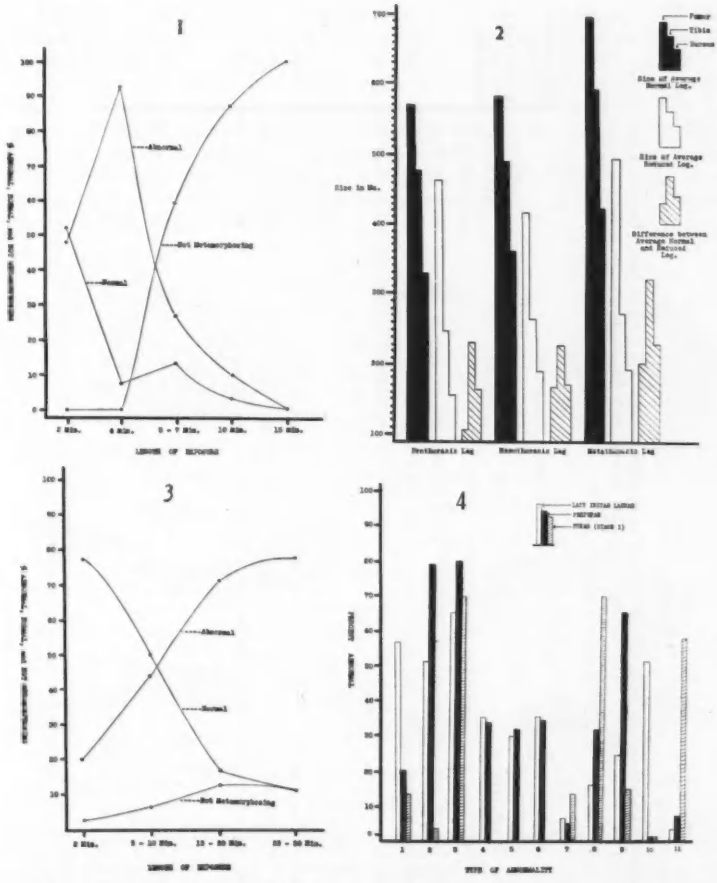
EXPERIMENTAL RESULTS

EFFECT OF VAPORS

Various stages of *Tribolium*, including immature larvae, last instar larvae, prepupae, and Stage I and II pupae, were subjected to the vapors of 30 cc. of glacial acetic acid for 15 minutes.

Affected Immature and Last Instar Larvae.—Immature and last instar larvae went into vigorous contractions and contortions and were inactivated after being subjected to acetic acid vapors for 15 minutes. None of these recovered and some became blackened entirely or in part while others were laterally compressed and distended.

Since a 15 minute exposure was lethal for larvae, last instar larvae were subjected to acetic acid vapors for various shorter lengths of time. The results are shown in graph 1. The 4 minute exposure was the optimum for producing abnormalities, since there was no mortality and a high percentage of abnormality. There was a high mortality beginning at the 5 minute exposure and this increased steadily until a mortality of 100% was obtained with a 15 minute exposure. The



GRAPH 1. Graph showing the percentage of abnormal, normal, and those not metamorphosing of last instar larvae subjected to the vapors of glacial acetic acid for various lengths of time. *Min.*—minutes.

GRAPH 2. A comparison of the sizes of normal and reduced appendages. (Data taken from table I.)

GRAPH 3. Graph showing the increase in the percentage of abnormal, and the decrease in the percentage of normal adults, with an increase in the length of exposure of prepupae to the vapors of glacial acetic acid. *Min.*—minutes.

GRAPH 4. Graph showing the frequency of the various abnormalities obtained after subjecting different stages of *Tribolium* to the vapors of glacial acetic acid for various lengths of time. 1. Individuals with abnormal antennae. 2. Individuals with abnormal mouthparts. 3. Individuals with abnormal legs. 4. Abnormal prothoracic legs. 5. Abnormal mesothoracic legs. 6. Abnormal metathoracic legs. 7. Appendages entirely missing or with coxa and trochanter present only or absent in part. 8. Appendages with abnormal femur and (or) tibia; malformed; tibia partly or entirely missing. 9. Appendages with abnormal tarsi; malformed; segments fused; no claws; tarsus missing entirely. 10. Appendages entirely or partly reduced and malformed. 11. Individuals with abnormal elytra.

TABLE I

TABLE SHOWING THE DRASTIC REDUCTION IN SIZE OF ADULT APPENDAGES AFTER EXPOSING LAST INSTAR LARVAE TO DIRECT APPLICATION OF HCl AND TO THE VAPORS OF ACETIC ACID. ALL MEASUREMENTS ARE IN MU.

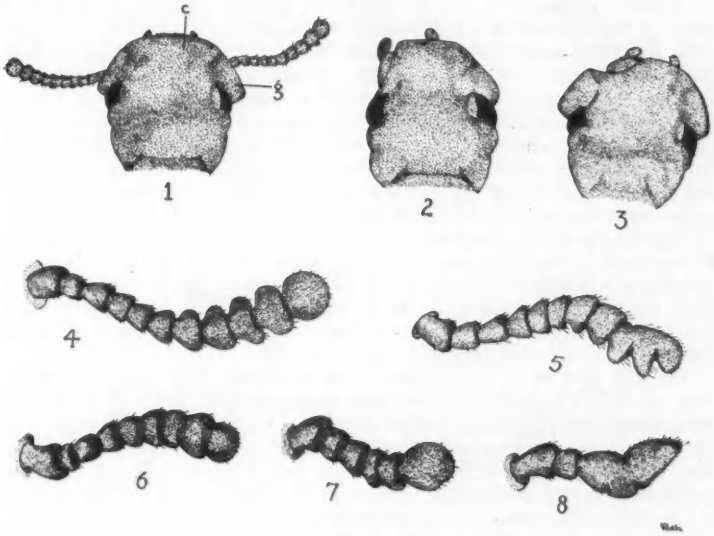
Max.—Maximum; *Min.*—Minimum; *Aver.*—Average.

SIZE OF NORMAL ADULT LEGS*				SIZE OF SOME ABNORMAL ADULT APPENDAGES																						DIFFERENCE BETWEEN AVERAGE NORMAL AND REDUCED APPENDAGE
PROTHORACIC LEG				19% HCl								Concentrated HCl				Vapors of Acetic Acid; 2-10 minute exposures										Reduced Appendages			
	Max.	*Min.*	*Aver.*																							*Max.*	*Min.*	*Aver.*	
Femur	600	500	569	400	528	440	312	480	496	480	488	480	488			440	400	480	520	480	456	440	520	496		528	312	464	105
Tibia	528	440	478	280	320	120	104	296	240	160	240	352	320			240	240	176	224	280	†	320	320	240		352	104	248	230
Tarsus	300	280	328	160	160	120	80	240	112	80	160	248	200			160	160	208	80	224	160	104	208	288		288	80	165	163
MESOTHORACIC LEG																													
Femur	600	536	581	520	280	480	480	440	480			400	504	504	464	160	536	304	448	320	440	320				536	160	416	165
Tibia	520	456	490	352	†	224	360	216	160			†	360	320	256	†	240	†	336	†	200	136				360	136	263	227
Tarsus	400	304	360	280	120	160	232	120	112			160	256	240	144	200	240	160	280	160	184	192				280	112	190	170
METATHORACIC LEG																													
Femur	760	640	695	496	440	480	528	320	320							440	624	640	560	632	640	496	440	344		640	320	493	202
Tibia	616	560	591	120	248	280	262	160	240							320	240	384	256	376	520	240	†	160		520	120	271	320
Tarsus	440	400	422	120	144	160	184	160	160							240	128	280	80	320	360	176	†	184		360	80	192	230

* Data taken from the measurements of the legs of 10 adults. Tarsal claws are not included in the measurement of tarsi.
† Missing from the appendage. These are not included in computing the average reduction.

sudden decrease in the percentage of abnormal individuals with the longer exposures (5 to 15 minutes) was due to this great increase in mortality.

A total of 66 abnormal individuals were obtained in these experiments. This number included a high percentage of leg (65.1%), antennal (56%), and mouthpart (51.5%) deformities. The different legs were about equally affected (graph 4, Nos. 4, 5, and 6). In a total of 102 abnormal legs, the most common leg deformity was a reduction in size (50.9%) and this was usually accompanied by malformation (figs. 24–28; cf. figs. 14–16).



FIGURES 1–8

Head and antennal abnormalities in *Tribolium confusum*. Figure 1. Head of a normal adult; *c*—clypeus, *g*—gena. 2 and 3. Heads of abnormal adults resulting from gassed Stage I pupae, showing abnormal gena and clypeus; the antennae, which are not figured, are normal. 4. A normal adult antenna. 5–8. Abnormal adult antennae resulting from gassed last instar larvae, showing reduction in number, fusion, and malformation of the segments. Magnification of figures 1–3, about 20×; of figures 4–8, about 38×.

This remarkable reduction is strikingly shown in both table I and graph 2. Although there generally was not a uniform reduction of all parts, occasionally some legs were reduced proportionately so that they looked exactly like normal appendages except for size. Frequently the coxa and trochanter were of normal size while the remaining parts were reduced. Abnormal tarsi was the next most frequent leg deformity (24.5%). These had fused segments, lacked segments, or were, occasionally, abnormally melanized. Two adults showed an increase in the number of tarsal segments (one right mesothoracic leg

and one right prothoracic leg had six segments instead of the normal five; fig. 22). In 17.6% the femur or tibia was abnormal, or the leg lacked the tibia partly or entirely; 6.8% lacked entire appendages or possessed only a coxa or trochanter.

Antennal segments were either fused, missing, or malformed (figs. 5–8). A few were not normally melanized. Of the mouthpart abnormalities, the labium and maxillae were often missing or reduced. Only 3% of the abnormal adults had an abnormal gena or clypeus, and 4.5% had deformed elytra (balloon-like swellings; partly missing; unmelanized).

Affected Prepupae.—Affected prepupae produced pupae with various parts of the appendages blackened, the degree of blackening varying with different abnormal individuals (see Roth and Howland, 1941, pl. II, figs. 10, 12). Pupae were also formed which lacked parts of the legs and mouthparts; some of these had a black or amber colored blob at the end of the remaining stump of the appendage, while others lacked this blob. The adults resulting from these pupae lacked the blackened pupal structures which were left behind in the moulted skin (see Roth and Howland, pl. II, fig. 13). Those parts that were missing in abnormal pupae were also missing in the adult.

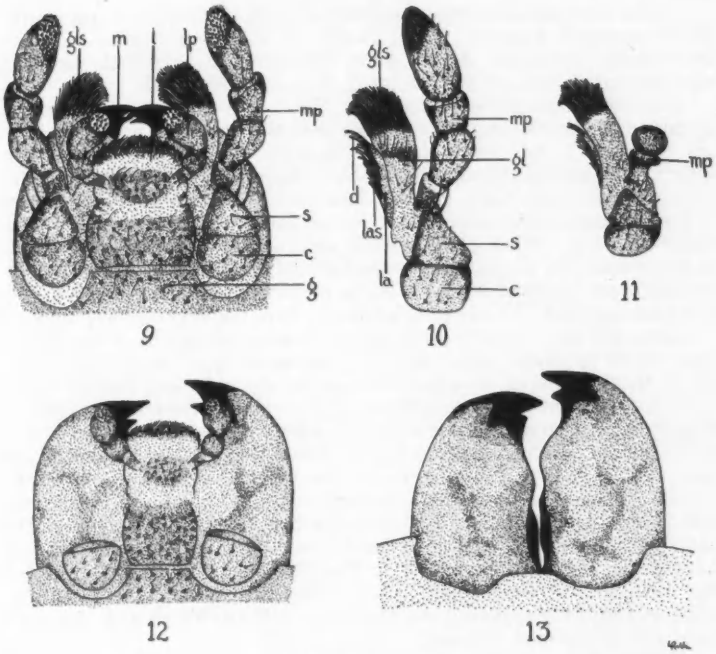
Eighty-three abnormal adults were obtained in these experiments. An analysis of the different types of abnormalities showed that the mouthparts (86.7%) and legs (78.3%) were more frequently abnormal than the antennae (20.4%); most individuals had both mouthpart and leg deformities. The pro-, meso-, and metathoracic legs were about equally affected (graph 4, Nos. 4, 5, 6).

Of 250 abnormal legs, tarsal abnormalities were more frequent than any other type (64%), the next abnormality in order of frequency being femur and tibial deformities (30.8%). Of the tarsal abnormalities, the absence of claws or lack of some segments were the most common (figs. 20, 21); the most frequent femur and tibial deformity was the femur having only part of the tibia attached (figs. 17–19). The absence of the entire appendage occurred only occasionally (5.2%).

Antennal deformities consisted of a fusion, lack, or reduction in size of some of the segments (figs. 5–8). Maxillary palps were frequently absent entirely or their segments were reduced in size (figs. 11, 12). An occasional but drastic mouthpart deformity was the absence of the maxillae and labium, in which case the mandibles (normally partly hidden by the labium and maxillae, fig. 9) were fully exposed and clearly seen from the ventral side (fig. 13). The brush-like galarastra and lacinarastra were also sometimes reduced. The labial palps were also affected while mandibular deformities were rare.

A number of individuals had difficulty in moulting their pupal skins and the exuviae would often cling to the elytra and abdomen. The resulting elytra were generally diverged and failed to harden and melanize normally. Some pupae failed to moult completely but continued to develop; in these, melanization and sclerotization continued and individuals were often obtained who possessed melanized areas like the adult (the head, thorax, antennae, legs, etc., a dark reddish brown), but the animals were still enclosed by their pupal skins.

Prepupae were subjected to the vapors of acetic acid for various lengths of time. There was an increase in the percentage of abnormal individuals and a corresponding decrease in the percentage of normal adults with an increase in the length of exposure. There was also a slight increase in mortality. This is shown in graph 3. An analysis of the various abnormalities found confirmed the previous results



FIGURES 9–13

Mouthpart abnormalities in *Tribolium confusum*. Figure 9. Mouthparts of a normal adult, ventral view (labrum not shown). 10. Maxilla of a normal adult. 11–13. Mouthparts of abnormal adults resulting from prepupae exposed to the vapors of acetic acid: 11, abnormal maxilla (all parts are reduced and the palp is malformed and composed of only two segments); 12, abnormal maxillae (only the cardo and a small portion of the stipes remain); 13, labium and maxillae entirely missing, exposing the mandibles. Figures 12 and 13 are ventral views; the labrum is present but is not shown. Abbreviations: *c*—cardo, *d*—distal hooks, *g*—gula, *gl*—galea, *gls*—galarastra, *l*—labium, *la*—lacinia, *las*—lacinarastra, *lp*—labial palps, *m*—mandibles, *mp*—maxillary palps, *s*—stipes. Magnification, about 50×.

obtained by a 15 minute exposure of prepupae to the vapors. The increase in length of exposure generally does not increase the degree of abnormality but merely the percentage of abnormal adults. Prepupae exposed for 2, 5, and 10 minutes gave essentially similar abnormalities as those developing from longer exposed prepupae.

We can conclude from graph 4 that the adults resulting from prepupae affected by acetic acid vapors have about the same percentage of mouthpart and leg deformities and these are much more frequent than antennal abnormalities. Any pair of the legs (pro-, meso-, or metathoracic) as regards to frequency, may be equally affected; tarsal abnormalities were most frequent with femur and tibial deformities next.

In the antennal deformities, segments 9 and 10 were most frequently fused: segments 4 and 5, 6 and 7, and 10 and 11 were also affected. Occasionally antennae lacked some segments, the eleventh segment was reduced in size, or the antennal club was abnormal.

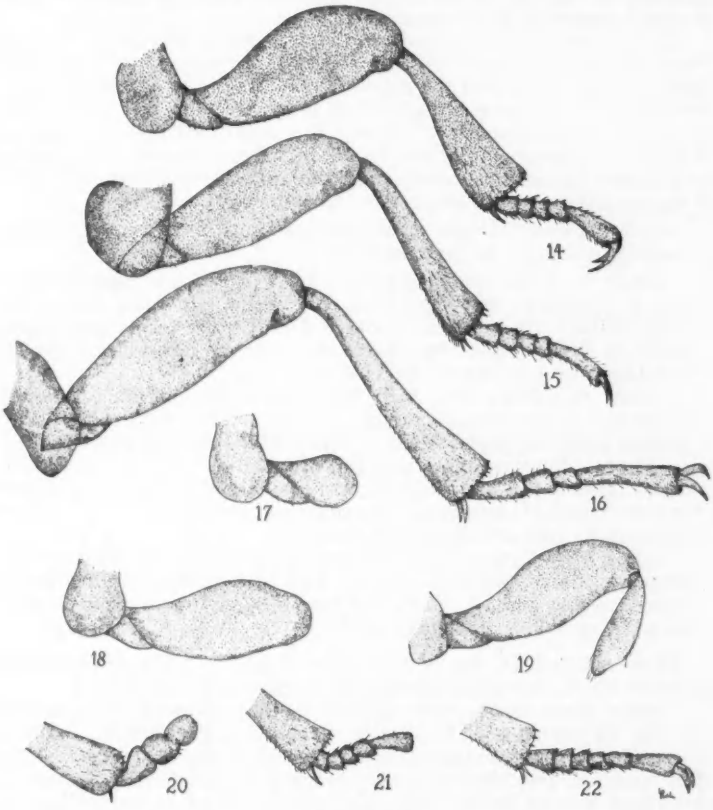
Since the prepupal stage may last about two days or a little more, prepupae of various ages were subjected to the vapors of acetic acid for ten minutes. Last instar larvae are very active, but just before entering the prepupal stage they become sluggish and move very little. However, although they cannot crawl about, they move their legs and twist their abdomens. Last instar larvae may be isolated and observed daily. When they become sluggish they may be considered as going into the prepupal stage and timed from that point on. The various ages used were: very early prepupae (still slightly active), about one day old, one day plus, and more than two-day old prepupae.

Although only 10 very early prepupae were treated, it is significant that all 10 produced approximately the same type of abnormalities. All of these prepupae moulted into pupae which lacked various parts of the legs, antennae, and mouthparts. Only two of the pupae possessed blackened appendages. The resulting adults lacked the parts missing in the pupae. In 59 abnormal legs only 15.2% had tarsal abnormalities (figs. 20, 21), 60.8% abnormalities of the femur and tibia (figs. 17–19), and 23.7% had the appendages entirely missing, or had only the coxa and trochanter present. All 10 individuals possessed abnormal mouthparts and antennae. The antennae generally lacked segments, or had some segments fused (figs. 5–8). The abnormal mouthparts were of the most drastic type where the maxillae and labium were entirely missing, thus fully exposing the mandibles (fig. 13) which in a few cases were also malformed (twisted).

Eleven of the 19 older prepupae (about one day and one day plus) that were treated, and 17 of the 20 abnormal prepupae, produced pupae with blackened appendages. These blackened structures were missing in the adults. Antennal abnormalities were infrequent (10.5%), while mouthpart deformities were common (84.6%) and more or less the same, generally affecting the maxillary palps which were usually malformed, reduced, or partly missing (figs. 11, 12). Of the leg abnormalities, tarsal deformities (58.5%) (figs. 20, 21) were more frequent than femur and tibial abnormalities (35%) (figs. 17–19), which in turn outnumbered the cases in which the appendages were entirely missing (6.5%). In the abnormal adults resulting from more-than-2-day-old prepupae, there was apparently little difference from the two preceding stages except that there was a decrease in the percentage of individuals with abnormal mouthparts (44.4%) (maxillary palp type).

Thus it is probable that the age of the treated prepupae determines the type and the degree of abnormality produced in the adult. Very

young prepupae, when treated, produced pupae lacking parts of appendages (few individuals blackened) and adults lacking parts of the femur or tibia, or lacking the entire appendage. Antennal segments were fused or missing, and maxillae and labium were also missing.



FIGURES 14–22

Normal and abnormal legs in *Tribolium confusum*. Figure 14. Normal adult prothoracic leg. 15. Normal adult mesothoracic leg. 16. Normal adult metathoracic leg. 17–21. Abnormal adult legs resulting from prepupae subjected to the vapors of acetic acid. 17. Abnormal prothoracic leg; part of the femur and the entire tibia and tarsus are missing. 18. Abnormal prothoracic leg; the tibia and tarsus are missing. 19. Abnormal prothoracic leg; part of the tibia and the entire tarsus are missing. 20. Abnormal metathoracic leg; one tarsal segment and the claws are missing; the other segments are malformed and partly fused. 21. Abnormal prothoracic leg; tarsal claws are absent. 22. Abnormal mesothoracic leg resulting from a last instar larva subjected to the vapors of acetic acid; there are six tarsal segments instead of the normal five. In figs. 20–22 the proximal portion of the leg is normal and is not figured. Magnification, about 35×.

Older prepupae when treated produced pupae with parts of appendages blackened. These necrotic areas (see Roth and Howland, 1941, p. 161), were missing in the adult. Tarsal abnormalities were more frequent than other types. There were few antennal deformities (as compared to those of legs and mouthparts), and mouthpart abnormalities were generally restricted to the maxillae.

This would explain the previous results and percentages obtained from treated prepupae. All experimental animals were originally sifted out from flour and the approximate ages of these prepupae were not known. It is very probable that most of the treated forms were about one day or more old. This would account for the low percentage of antennal deformities and also for the fact that so few of the abnormal mouthparts lacked the maxillae and labium entirely, and that most of the leg abnormalities were of the tarsal type.

Affected Pupae.—Pupae were separated into four different stages according to changes in pigmentation:

Stage I.—Pupa completely white or light tan; eye pigmentation, just at pupation, very light and only a few individual facets distinguishable. At the end of Stage I individual facets are clearly seen but the interfacet spaces are still more or less white. (About 1–5 days after pupation at 29° C.)

Stage II.—Pupa light tan; eye pigmentation black. Although individual facets are discernible, the interfacet spaces have also become darker in pigmentation. (About 6 days after pupation.)

Stage III.—Eyes black and tips of mandibles darkly pigmented; tarsal claws brown and easily discernible; tarsal segmentation absent or very indistinct; antennae and remaining portion of the legs not yet pigmented. (About 7 days after pupation.)

Stage IV.—Eyes and tips of mandibles black; genae dark brown; antennae, tibiae and tarsi light or dark brown; tarsal segmentation clearly visible and the claws moving freely within the pupal skin. (About 7 or 8 days after pupation.)

Stage III and IV are of very short duration. The entire pupal period at 29° C. (humidity uncontrolled) lasts about 7 or 8 days.

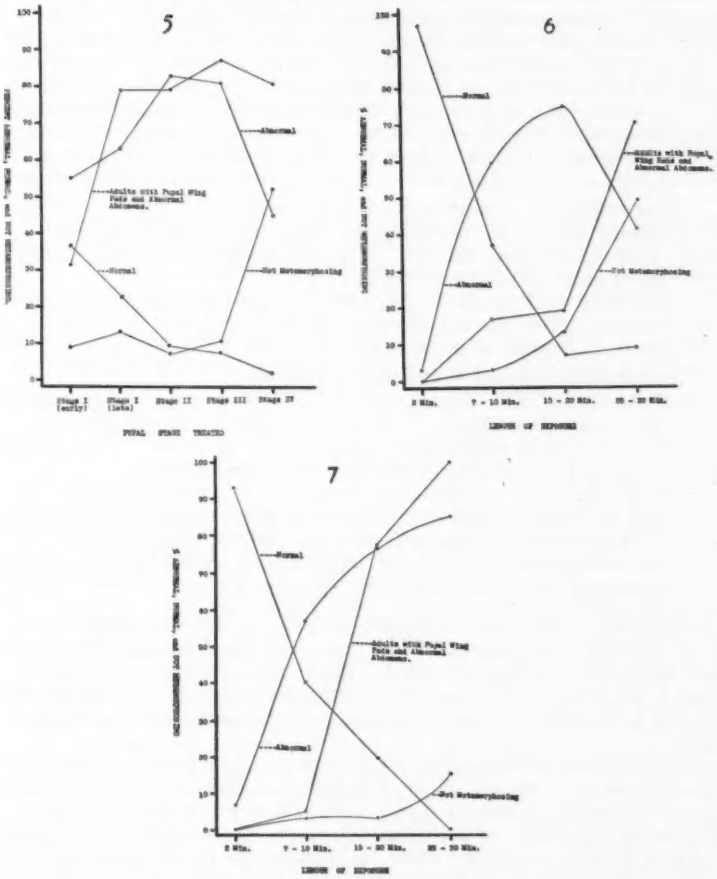
Various pupal stages were exposed to the vapors of glacial acetic acid for 15 minutes. The results are shown in graph 5. With a 15 minute exposure, apparently, early Stage I pupae (pupae shortly after pupation) give the lowest percentage abnormality and the highest percentage normal individuals. The percentage of abnormal beetles increases with Stages I (late), II, and III, and suddenly falls with individuals from Stage IV. This drop is undoubtedly due to the sudden increase in mortality obtained from treated Stage IV pupae (graph 5). There is a slight fluctuation in mortality from Stages I–III. The percentage of normal beetles decreases with the increase in age of treated pupae.

It is also interesting to note that the number of abnormal beetles possessing pupal wing pads and abnormal abdomens was lowest from Stage I pupae (early) and high in all other treated stages.

The various types of abnormalities obtained from the different pupal stages may be listed as follows:

Abnormalities obtained from Stage I pupae (see graph 4):

1. Abnormal elytra; elytra diverging, parts missing, unmelanized and unsclerotized (figs. 30–34).
2. Abnormal heads; parts of the genae or clypeus missing (figs. 2, 3).
3. Various parts of the legs missing (figs. 17–19). These had remained pupal and were left behind with the exuviae.



GRAPH 5. A comparison of the percentage of abnormal, normal, and those not metamorphosing of the different pupal stages subjected to the vapors of acetic acid for 15 minutes.

GRAPH 6. Graph showing the results obtained by exposing Stage I pupae to the vapors of acetic acid for various lengths of time. *Min.*—minutes.

GRAPH 7. Graph showing the results obtained by exposing Stage III pupae to the vapors of acetic acid for various lengths of time. *Min.*—minutes.

4. Abnormal antennae; some of the segments may be fused or missing.
5. Adults with pupal wing pads and abdomens. Many of these also possessed pupal appendages. Since they generally fail to moult these pupal structures usually remained attached to the adult.

Abnormalities obtained from Stage II pupae:

1. Elytral abnormalities; diverging or wrinkled (fig. 33).
2. Various parts of the legs missing or not normally melanized.
3. Antennal segments may be fused or unmelanized.
4. Individuals with pupal wing pads and abdomens; the abdominal sclerites may become lightly pigmented or may be melanized in isolated regions only (parts of the sclerites pigmented only; remaining portions colorless). The appendages may remain partly or entirely pupal.

Abnormalities obtained from Stage III pupae:

1. Elytra abnormal; diverging or with balloon-like swellings at their bases (figs. 33, 35). These swollen areas are generally unmelanized and appear pupal.
2. In those individuals that moult, various parts of the legs are missing or are not melanized normally.
3. Same as number 4 under Stage II.

Abnormalities obtained from Stage IV pupae:

1. Individuals with pupal wing pads and abdomens (generally fail to moult normally). The elytra may become dark brown but still remain wrinkled and pupal-like in character. Abdominal sclerites may become pigmented in certain areas only or they may also become normally pigmented. Various parts of the legs are also abnormally pigmented (very light as compared to the normally pigmented structures on the same animal).
2. In individuals that moult normally, various parts of the appendages may be abnormally pigmented.

It will be noted that only from early Stage I pupae were elytra obtained with parts missing. Older pupae produced adults with elytra that were diverging or possessed balloon-like swellings. Also, early Stage I gave more antennal abnormalities than any of the others and was the only stage (of treated pupae) that produced abnormal adult heads.

To determine if the length of exposure had any effect on the type of abnormality produced, Stage I pupae were subjected to the acid vapors for various lengths of time. The results are shown in graph 6. The percentage of normal individuals decreases steadily with an increase in the length of exposure, while the percentage of abnormal adults increases up to the 15–20 minute exposure, and suddenly drops at the 25–30 minute exposure, due to the high increase in mortality. Further tests showed that pupae about one day old give a high percentage of mortality when subjected to the vapors for 30 minutes. The percentage of individuals with pupal wing pads and abnormal abdomens increases suddenly between the 15–20 and 25–30 minute exposures.

An analysis of the various types of abnormalities in the 76 abnormal

adults (graph 4) showed that the most frequent types are individuals with abnormal legs (69.7%) and elytra (57.8%). Of the leg abnormalities (95), absence of parts of the tibia or femur was most common (69.4%); 16.8% were of the tarsal type, and 13.6% lacked entire appendages or possessed only a coxa and trochanter. Only 17.1% possessed abnormal heads and 13% had abnormal antennae. Mouthpart abnormalities were rare (3.9%).

Stage III pupae were also subjected to the vapors for various lengths of time. The results are shown in graph 7. There is a steady decrease in normal and increase in abnormal beetles with increase in length of exposure. At this stage the percentage mortality does not go as high as that obtained from Stage I pupae (cf. graph 6). It will also be noted that the percentage of individuals with pupal wing pads and abnormal abdomens increases rapidly from exposures of 7–10 minutes and reaches 100% at 25–30 minute exposures (as compared to 70% from Stage I pupae).

The abnormalities were typical for this stage. Various parts of the appendages were missing (from those pupae which moulted). Elytra were diverging, swollen or unmelanized (rarely with parts missing—only one case). Parts of the appendages were unmelanized.

Apparently the length of exposure does not affect the type of injury but merely the percentage abnormality, normality, etc. From these experiments we may conclude that the age of the treated pupa determines, more or less, the type of injury obtained.

EFFECT OF DIRECT APPLICATION OF CHEMICALS

The Application of Crystals of the Odoriferous Substance of Adult Tribolia.[3]—To check on the previous results obtained by the direct application of the odoriferous substance to the leg region of last instar larvae (Roth and Howland, 1941), these crystals were again applied to 17 mature larvae. Six abnormal adults (35%) were obtained. One had a mesothoracic leg completely duplicated (see Roth and Howland, pl. I, fig. 5). The others had extra tarsal branches growing from the tibiae, while one interesting monstrosity apparently had made an attempt to form three separate legs from one imaginal disc (fig. 23).

The Application of 10% *HCl.*—In the experiments in which 10% HCl was applied to immature larvae 2.5–4.0 mm. long, four abnormal adults were obtained. One adult had an antennal club with fused segments; two others had a reduced and malformed mesothoracic and prothoracic leg, respectively, while the fourth had difficulty in moulting.

When 10% HCl was applied to immature larvae 4.5–5.0 mm. long, one of the five abnormal adults obtained had an abnormal tarsus; three others lacked parts of legs; the last had a reduced mesothoracic leg (about half normal size) and a reduced and malformed metathoracic leg.

The nine abnormal adults resulting from prepupae treated with 10% HCl lacked parts of legs or had abnormal tarsi. One failed to moult and another had difficulty in moulting because of a blackened region between the second and third abdominal sclerites which prevented the pupal skin from being sloughed off.

[3]See Footnote 2, p. 235.

The Application of 19% *HCl.*—When 19% HCl was applied to immature larvae 2.5–4.0 mm. long, two abnormal adults were obtained; one had the ninth and tenth segments of the right antenna partly fused, and the other had a small spur-like outgrowth on the tibia of the right metathoracic leg.

Immature larvae 4.5–5.0 mm. long treated with 19% HCl produced seven abnormal adults; one had malformed maxillary palps; the others lacked legs entirely, or lacked parts of legs, and had reduced and malformed appendages.

Treatment of last instar larvae with 19% HCl resulted in 24 abnormal adults that lacked parts of or entire legs, had abnormal tarsi (segments fused or missing), and had reduced and malformed legs (figs. 24–27, table I, and graph 2). In addition, two of these had an abnormal antenna (some of the segments fused), and two others had abnormal mouthparts (parts missing, and maxillary palps reduced).

Three larvae moulted into larvae with pupal characters (pupal wing pads and legs, but with larval abdomen and head). The antennae were neither pupal nor larval. These were almost identical with those reported and figured by Nagel (1934, figs. 2–4), obtained by subjecting mature larvae to various low temperatures. The present writer found three more of these metathetelous larvae in a culture of larvae reared away from adults. It is probable that the acid had little, if anything, to do with the production of these monsters. Similar abnormalities have been produced by subjecting mature larvae to high temperatures and to the vapors of carbon dioxide (Oosthuizen and Shepard, 1936).

The 34 prepupae treated with 19% HCl produced pupae lacking and with blackened structures. These produced adults with parts of the legs, mouthparts, and antennae missing. Leg abnormalities were most common.

Four of the eight abnormal adults resulting from pupae treated with 19% HCl could not get fully out of their pupal skins. Parts of the legs remained pupal. Two others had abnormal tarsi, and the others had parts of the legs missing (one of these also had the genae modified and a left maxillary palp missing).

The Application of Concentrated HCl.—When concentrated HCl was applied to last instar larvae, all of the 26 abnormal adults produced had abnormal legs, which were missing partly or entirely or were reduced and malformed (fig. 28; see also figs. 24–27, table I, and graph 2). One adult had an antenna of only three segments.

Affected prepupae gave the typical abnormalities. Large areas of the pupal legs were blackened and hardened. Those that metamorphosed lacked these structures.

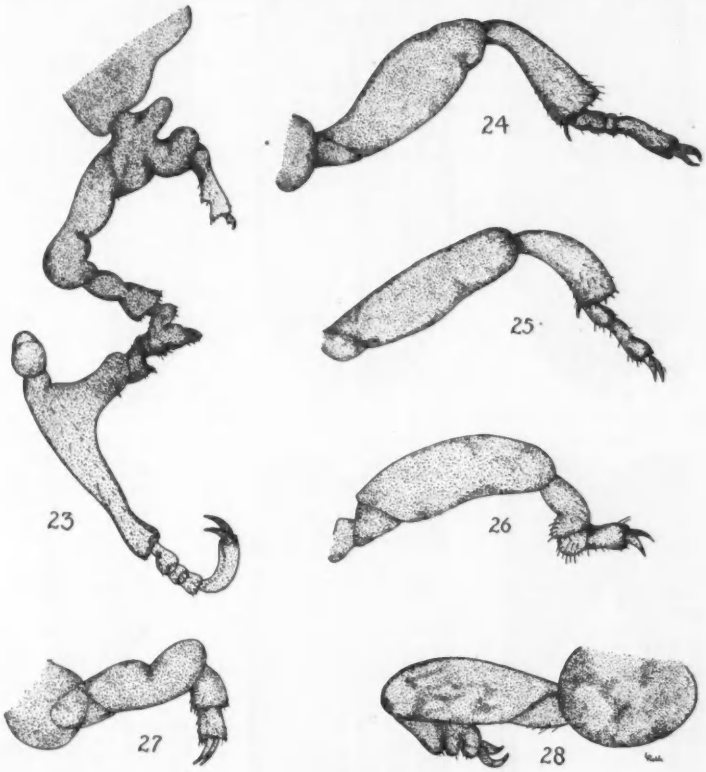
In the case of treated pupae of Stage I, the parts affected remained soft and white, and as usual were left behind in the moulted pupal skin.

The Application of Glacial Acetic Acid.—Glacial acetic acid was applied directly to last instar larvae, prepupae, and Stage I pupae. When applied to last instar larvae, the legs of the resulting adults were malformed, reduced, or had various parts missing. Tarsal segments were fused, or claws were absent. A few individuals had abnormal antennae and one interesting individual lacked part of the thorax.

Prepupae treated with glacial acetic acid produced pupae with

various appendages brownish black. In some, tarsal segments and other parts were missing. The resulting adults lacked parts of the legs.

Five of the abnormal adults resulting from Stage I pupae treated with glacial acetic acid could not emerge normally. The elytra were

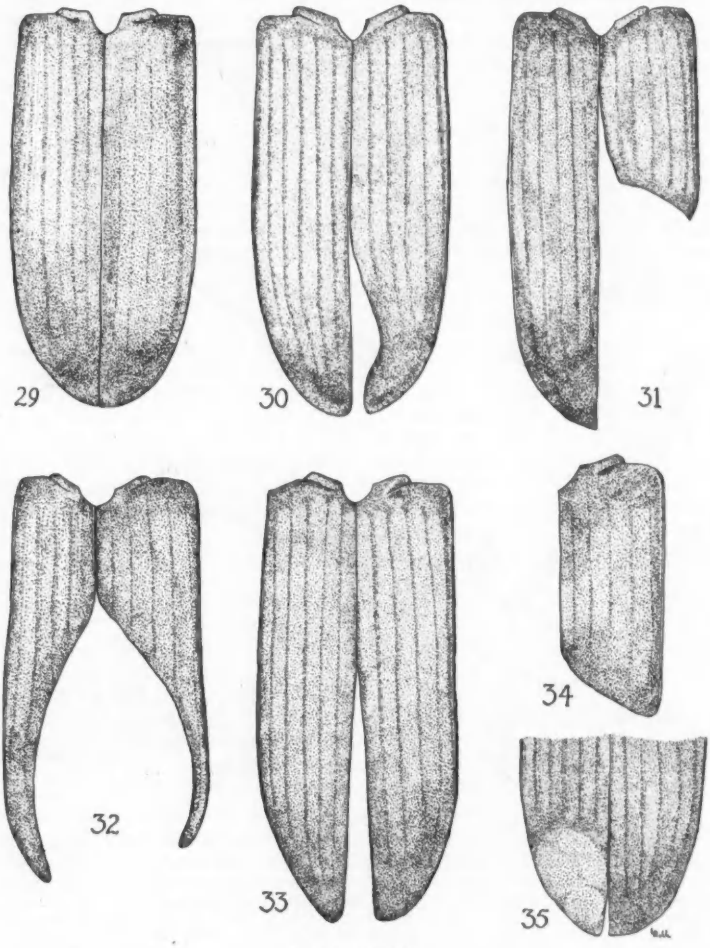


FIGURES 23–28

Tarsal abnormalities in *Tribolium confusum* (compare size and shape with figs. 14–16). Figure 23. Abnormal metathoracic leg obtained by applying crystals of the adult odoriferous secretion to the leg region of the last instar larva; an attempt has been made to form three legs. 24–27. Abnormal legs obtained by applying 19% HCl to the leg region of last instar larvae; all are reduced and malformed. 24. Abnormal prothoracic leg; there are only 4 tarsal segments and the first two are partly fused. 25. Abnormal mesothoracic leg; only two tarsal segments are present. 26. Abnormal metathoracic leg; only two tarsal segments are present. 27. Abnormal prothoracic leg; the tibia is absent and there are only two tarsal segments. 28. Abnormal mesothoracic leg obtained by applying concentrated HCl to the leg region of a last instar larva; the tibia is missing and only 3 tarsal segments remain, these being partly fused. Magnification, about 35×.

Abnormalities more or less similar to those in figs. 24–28 were also obtained from last instar larvae exposed to the vapors of glacial acetic acid.

abnormal and the abdomen remained soft and white. The others had abnormal tarsi and one also had a reduced maxillary palp and lacked the right elytron.



FIGURES 29–35

Elytral abnormalities in *Tribolium confusum*. Figure 29. Normal adult elytra. 30–34. Abnormal adult elytra obtained by subjecting Stage I pupae to the vapors of acetic acid. 30. Small portion of the right elytron missing. 31. About one-half of the right elytron missing. 32. Parts of both elytra missing. 33. Diverging elytra. 34. Part of the right and entire left elytron missing. 35. A balloon-like swelling at the base of the left elytron resulting from a Stage III pupa subjected to the vapors of acetic acid. The basal portions of the elytra are normal but not figured. Magnification, about 20×.

DISCUSSION

EFFECT OF VAPORS

The experiments have shown that acetic acid vapors can induce the same abnormalities in *Tribolium confusum* as those obtained with the fumes of the odoriferous substance given off by the adults. A careful analysis has been made of the various types of abnormalities obtained from treating different stages of the beetle.

Although the vapors had been applied more or less diffusely, localized defects were produced. As Weiss (1939, p. 159) points out, this is undoubtedly due to the fact that the organism has the property of differential susceptibility, that is, there are some parts that are more sensitive than others and the same agent will affect some parts more strongly than others. "The striking parallelism between the gradient of susceptibility and that of metabolic rate has led to the contention that increased metabolic activity implies greater sensitivity. . . ." (p. 376).

In the present work, it has been shown that the type of abnormality obtained depends on the stage treated. The predominant types are listed in table II.

TABLE II

PRINCIPAL DEFECTS PRODUCED IN ADULTS OF *Tribolium confusum*

STAGE TREATED	PREDOMINANT TYPE OF ADULT DEFECT (more than 25%)
Last Instar.....	1. Antennal deformities; segments fused or missing. 2. Mouthpart deformities; usually labial abnormalities (missing or reduced); maxillae may also be affected. 3. Leg deformities; entire or parts of legs reduced and malformed.
Prepupae (early).....	1. Antennal deformities; segments fused or missing. 2. Mouthpart deformities; labium and maxillae missing. 3. Leg deformities; parts of tibia or femur missing.
Prepupae (late).....	1. Mouthpart deformities; maxillae usually abnormal (palps reduced or missing). 2. Leg deformities; tarsal abnormalities; absence of parts of tibia or femur.
Pupae (Stage I).....	1. Leg abnormalities; parts of femur and tibia generally missing. 2. Elytral deformities; diverging; parts missing or unmelanized. 3. Adults with pupal wing pads and abnormal abdomens. These may also possess pupal legs.
Pupae (Stages II–IV)..	1. Adults with pupal wing pads and abnormal abdomens. Many may also possess pupal appendages. 2. Those that develop and moult may lack parts of legs or have abnormally melanized appendages.

Gassed last instar larvae produced adults with reduced and malformed appendages. In these larvae the cells of the imaginal discs were undoubtedly more or less equipotential in character, for although part of the disc had been injured or destroyed, it had still developed into an entire, though dwarfed, appendage. The appendage may also be

deformed, but in most cases the femur, tibia, and tarsus are all distinguishable.

Some adult legs from gassed last instar larvae were also partly or entirely missing. It might be argued that as the larvae become older the imaginal discs become more "determined" for the various parts of the legs so that any damage inflicted at this later stage would entail a corresponding defect in the appendage (lack of parts). However, although there may be such a critical period when the disc becomes "determined," this has not been shown in these experiments; it will be recalled that the direct application of 10% and 19% HCl to immature larvae also produced some adults with reduced and malformed and also missing appendages. This still leaves the possibility that the toxic substance may injure too much of an area to permit "regulation" (the formation of a whole, but reduced limb, from only a portion of the imaginal disc).

Bodenstein (1941) has shown that the legs of Lepidoptera in later caterpillar stages are still capable of "regulation," while in Diptera all major leg structures are already determined in corresponding stages.

In the previous work (Roth and Howland, 1941) with the vapors and crystals of the odoriferous substance, it was reported that affected last instar larvae gave only antennal and head deformities when treated with the vapors, while both leg and antennal abnormalities were obtained with the crystals. It was suggested that this was due to the greater toxicity and penetrating power of the melting crystals. In the present experiments, not only were antennal defects obtained but legs and mouthparts were also malformed. Acetic acid vapors are undoubtedly much more penetrating than those of the odoriferous substance. An exposure of only 2–4 minutes to the acid vapors gave a high percentage of abnormalities, while in the original work larvae were subjected to the odoriferous vapors for one hour and fifteen minutes.

It has been noted that there is a shift in the type and degree of abnormality with the developmental stage treated (graph 4). Abnormal adults obtained from treated prepupae and pupae usually lacked some structure. Again this is explained by Weiss (1939, pp. 482–483): "If a part drops out after a mosaic state has been attained the loss is permanent. . . . Differential susceptibility to the toxic agent likewise accounts for the suppression of localized parts. Which parts are suppressed depends on the developmental stage of the organism at the time when the agent strikes, since susceptibility varies with the degree of activity (metabolism?) *and the centers of developmental activity shift from stage to stage.*"

It is interesting to note that in some cases the distribution of melanin seems to be related to the intensity of metabolism in the subjacent tissues (Wigglesworth, 1939, p. 333). Since, in *Tribolium*, the tarsal claws are among the first structures to become melanized (in the pupa), one might say that the cells of this region are probably more active than those in other parts of the leg, throughout its formative period; many treated prepupae produced adults lacking tarsal claws or possessing other tarsal abnormalities. It should be remembered, however, that the tips of the mandibles become pigmented at about the same time as the tarsal claws, and although mouthpart deformities were obtained from treated prepupae, very few affected the mandibles specifically.

Early prepupae may moult into pupae lacking parts of the appendages. Apparently the legs, mouthparts, and antennae of this stage are still in the formative stage and have not been everted; when parts are destroyed at this time, they are missing from the pupae and consequently from the adults. Later prepupae produce pupae with necrotic appendages and these were affected after the appendages had already been evaginated. Horsfall (1934) also found that prepupae of *Tribolium* give rise to more abnormalities than pupae when given the same dosage of ethylene oxide vapors.

The prepupal stage (particularly the early prepupa) is the most critical in the development of *Tribolium*, for it is at this period that the most drastic abnormalities can be induced. However, prepupae can withstand longer exposures than either larvae or pupae. A comparison of mortality curves (graphs 1, 3, 6, 7) shows that all larvae are killed by a 15 minute exposure, whereas prepupal mortality did not exceed 10%, and the highest mortality for Stage I and III pupae (for exposures between 2–15 minutes) was 6.6%. In one experiment Stage IV pupae gave a 54% mortality after a 15 minute exposure (see graph 5). Between exposures of 15 and 30 minutes, prepupae and Stage III pupae reached a mortality peak of 20% while the mortality of Stage I pupae rose to 66.6%.

Wigglesworth states (1939, p. 340) that metabolism at a given temperature is generally much higher in the larva than in the pupa, this being mainly the result of differences in muscular activity. The oxygen intake is also greater in active insects. This may explain the death of all larvae after 15 minutes whereas the other stages can withstand longer exposures. Larvae, being more active, take in more oxygen, and consequently more vapors of acetic acid. The high mortality of Stage I pupae (particularly early Stage I) is undoubtedly due to the soft and permeable condition of the still unsclerotized cuticle, through which the vapors can readily penetrate. Moore (1916) has shown that gases can penetrate through other parts of the body than the spiracles (through thin layers of chitin). However, Stage IV pupae also gave a high mortality and by this time the cuticle has become more hardened.

Affected pupae often produced adults with abnormally melanized regions and many beetles possessed an entirely unpigmented or only partly pigmented abdomen. It is well known that the deposition of melanins requires the interaction of tyrosinase, chromogen, and oxygen. "In general it seems to be the localization of chromogen which determines the distribution of the pigment patterns; chromogens are absent from white areas of cuticle whereas tyrosinase is present everywhere" (Wigglesworth, 1939). Thus it is highly possible that in these abnormally pigmented individuals the formation of chromogen has been interfered with. Oosthuizen (1935) also found that many adults developing from pupae exposed for short periods to 44° C. had deformed wings or a pupa-like abdomen.

EFFECT OF DIRECT APPLICATION OF CHEMICALS

The direct application of concentrated acetic acid and various concentrations of hydrochloric acid to the different stages of *Tribolium* produced essentially the same results as those obtained by the use of acetic acid vapors. In all larvae treated there was only one case of an

adult with an accessory outgrowth (an immature larva treated with 19% HCl produced an adult with a small spur-like outgrowth from the tibia).

Thus the leg deformities obtained with various chemicals were different from those obtained with the crystals of the odoriferous substance. In no case were duplications or tarsal-like outgrowths obtained with the former. It was originally suggested that regeneration of injured discs resulted in these duplications. However, if this is the case, it is unusual that similar deformities were not obtained after injury with HCl or acetic acid (an injury which was not too drastic to prevent the formation of a reduced appendage). Actually the duplication may have resulted from a splitting of the disc by the toxic agent. As Weiss points out (1939, p. 482), "Accidental splitting of the company of cells in the germ (in the preliminary phase, prior to final determination), may cause twinning and when the same accident happens to an organ rudiment in its equipotential state, reduplications of various degrees may be produced."

However, this still does not explain the fact that this type of injury was not obtained with the use of other chemicals. From the various outgrowths also obtained with the odoriferous crystals, there seems to be a tendency toward a stimulation of growth (see fig. 23). So we finally return to Chapman's (1926) original suggestion that the odoriferous substance of *Tribolium* may have a tendency to stimulate when given in a minimum dose, while in a maximum dose it may be lethal.

SUMMARY

1. Various stages of *Tribolium* have been subjected to the vapors of acetic acid. The results were more or less similar to those obtained with the vapors of the odoriferous substance given off by the adults. In the present work a detailed analysis has been made of the types of abnormalities produced. The type of deformity induced is determined by the developmental stage of the animal at the time of treatment; and this type changes with a change in the developmental stage.

2. Glacial acetic acid and various concentrations of hydrochloric acid were also applied directly to different stages of *Tribolium*. The results were essentially the same as those obtained by the use of acetic acid vapors. In only one case was an accessory outgrowth induced and never were any duplications or triplications obtained.

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NOTES ON ECUADORIAN BUTTERFLIES. IV. THE GENUS PENROSADA, NEW

(Lepidoptera, Satyridae)

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The members of the genus *Penrosada* have heretofore been placed in the genus *Lymanopoda*, but they differ from the species which really belong to *Lymanopoda* both superficially and structurally. Superficially, they are smaller, and have a normal wing shape; the most striking structural differences are to be found in the male genitalia. There is marked uniformity in the trend of variation within each species. On the east slope of the Andes these insects seem to be restricted to the temperate forests, and they abound in the more moist regions near the tree line; on the western slope they descend into the subtropics.

I wish to thank the following men and institutions for allowing me the privilege of examining material in their charge: Mr. William P. Comstock, of the American Museum of Natural History; Dr. J. W. Cadbury 3rd, of the Academy of Natural Science, Philadelphia; Dr. William D. Field, of the U. S. National Museum; Dr. A. A. Avinoff, of the Carnegie Museum, Pittsburgh; and Dr. W. T. M. Forbes, of Cornell University. Dr. Field kindly made the dissection of the type of *P. keithi* and sent me drawings from which I drew the figure here presented (fig. WDF).

Penrosada, new genus

Eyes usually glabrous to very weakly haired; antennae composed of 38 segments, of which 10 or 11 form the club (fig. 1669F); palpi similar to those of *Lymanopoda*, but much more densely haired (fig. 1669E). Prothoracic legs similar to those of *Lymanopoda* (fig. 1669C).

Fore wing with costal margin generally less than an inch in length, the costal and outer margins gently curved; apex of wing angular, sometimes sharply so but never produced or falcate. Hind wing with outer margin smoothly rounded or slightly undulant, never angular; anal margin usually slightly incised near anal angle. Venation of fore wing similar to that of *Lymanopoda*, particularly bases of veins and branching of radius, but differing in lacking medial stalk and crossvein connecting radius with M_1; M_1 originating on radius (fig. 1669A). Venation of hind wing differing from that of *Lymanopoda* in that the crossvein between M_1 and M_2 is shorter and more gently curved, and M_3 lies much closer to Cu_1 than to M_2 (fig. 1669B).

Variation in male genitalia from species to species less striking than in *Lymanopoda*. Uncus simple, about as long as or longer than "shoulder" of vinculum; two prominent subuncal prongs; vinculum slender; saccus short; valves small, with a well developed sacculum; distal process present, but no dorsal process in any of the species

examined; tip of distal process armed with a few large teeth; aedeagus short, curved, heavy, often "humped" toward the base, not toothed.

Type.—*Lymanopoda leaena* Hewitson.

I have named this genus in honor of Mr. Spencer Penrose, founder of the Cheyenne Mountain Zoological Society and Museum, who generously made available the funds to include a botanist in our field party in Ecuador.

KEY TO THE SPECIES OF PENROSADA

1. Neither light spots nor a light band across under side of hind wing.....2
   Either light spots or a light band across under side of hind wing.....5
2. A discrete partial row of pupillated spots on upper side of hind wing.....3
   These spots lacking.....4
3. A definite but obscure reddish brown transverse band on under side of hind wing.....**apiculata** (Felder)
   This band lacking.....**cillutinarca** Weymer
4. A row of white spots on under side of hind wing, at least some of which are surrounded with black.....**cillutinarca** Weymer
   These spots lacking.....**lanassa** f. **neglecta**
5. A transverse row of light spots on under side of hind wing.....6
   A solid light band across under side of hind wing.....7
6. At least seven spots on under side of wing, the outer margin of the row straight.....**lanassa** f. **discontinua**
   Four or five spots on under side of wing, the outer margins of these rounded, **apiculata** f. **interrupta**
7. A bright burnt orange band across upper side of hind wing, or a large diffuse area of rusty brown at anal angle.....8
   Upper side of hind wing more or less concolorous.....9
8. A bright burnt orange band across upper side of hind wing.....**lisa** Weymer
   A lafge area of rusty brown on upper side of hind wing, at anal angle, **lisa** f. **reducta**
9. Light band across under side of hind wing uniform in width..**leaena** (Hewitson)
   This band irregular in width.....10
10. A strongly developed submarginal row of ocelli on under side of hind wing...11
    At most only discrete ocelli on under side of hind wing.....12
11. An ocellus on under side of fore wing.....**satura** Weymer
    No ocelli on under side of fore wing.....**keithi** Dyar
12. A partial row of discrete ocelli on upper side of hind wing, **apiculata** f. **curvilinea** (Weymer)
    These ocelli absent.....**lanassa** (Felder)

Penrosada leaena (Hewitson)

Figures 1613 and 1669

1862. Hewitson, Jour. Entomology, 1: 156, pl. 9, fig. 1.

Type Locality.—Columbia (?).

Range.—Columbia, Ecuador, and Bolivia.

Material Examined.—Tungurahua, Ecuador: 7♂ and 2♀ 22.XI.38, 2800 m. (F. M. B.), and 2♂ 9.I.39 (W. C.–M.), Runtún, near Baños; 5♂ 1.XII.38, 2300 m. (W. C.–M.), Pundoa, near Baños; 1♂ 15.X.38, 2200 m. (W. C.–M.), San Pablo, near Baños; 1♂ X.38, 2200 m. (W. C.–M.), 1♂ 14.V.39, 2000 m. (W. C.–M.), 1♂ 5.I.39, 1900 m. (W. C.–M.), 1♂ 8.XI.38 (W. C.–M.), 1♂ 18.X.38, 1700 m. (W. C.–M.), and 1♂ II.39 (J. E. S.), Baños; 4♂ 18.X.38, 2000 m. (W. C.–M.), Rio Blanco, near Baños; 1♂ X.39, 1400 m., (J. E. S.), Chinchin Grande; 1♂ 1.X.38, 1200 m. (F. M. B.), Hda. San Francisco.

This species is quite common in the temperate and upper subtropical forests. Whymper collected two specimens at Machachi, 10,000 feet elevation, in the semi-arid interandean plateau. Stübel took it on the road from Quito to Manabi, between 2500 and 2800 meters. Dognin reported it among Gaujon's catches in the "vicinity of Loja." At least one of these Dognin specimens is a form of *apiculata*. Coxey collected two specimens at Hda. Licay, above Huigra, 7000 feet, 29.VII.32, on the western slope. Bolivia is included in the range of this species on the basis of a specimen from Cochabamba collected by José Steinbach and in the Carnegie Museum (Acc. 6873). Kirby gives Nauta as a locality for the species in his catalogue (p. 102); this is obviously incorrect.

Penrosada apiculata (Felder)

Figure 1622

1867. Felder, Reise Novara, Lepidoptera, 3: 474.
Synomyn: *harknessi* Dyar, Proc. U. S. N. M., 45: 634; 1913.

Type Locality.—Bogota, Colombia (Lindig).

Range.—Colombia to Peru.

Material Examined.—Azuay, Ecuador: 1♂ 15.II.39, 2700 m. (F. M. B.), Seville de Oro; 1♂ 16.II.39, 2800 m. (F. M. B.), trail between Pan and Paute.

These two specimens were taken in the semi-arid grasslands—bush country of the temperate region. They differ in minor respects from the descriptions of the species and from Weymer's figure in Seitz'. The rusty markings on the under side of the hind wings are quite obscure, and the lilac-gray margins of the same surfaces are broader. On the upper surface of the hind wings there is a pair of tiny white-pupilled ocelli. Until these specimens are carefully compared with a reasonably long series of Colombian specimens I feel that it is better to leave them unencumbered by a subspecific name.

The male genitalia of *apiculata* (fig. 1622) are much like those of *leaena* (fig. 1613). They differ slightly in the shape of the distal process of the valve and of the aedeagus. However, I would hesitate before separating the two species solely on the basis of genitalia.

Penrosada apiculata form **interrupta** new form

Figure 1618

Holotype.—♂ 15.II.39, 2500 m., Seville de Oro, Azuay, Ecuador (No. B1618). *Paratypes*: 1♂ 1.VIII.32 and 1♂ 25.VII.32, 4000 ft. (W. J. Coxey), Huigra, Ecuador (Acad. Nat. Sci. Phila.).

The holotype of this interesting form was collected in a dry grassy field on the steep slopes lying east of the town. It differs from typical *apiculata* in having a row of four creamy white spots across the disc on the obscure rusty red band on the under side of the hind wings. The costal spot of the four is minute, and the one on the anal margin is double. These spots are subtriangular in shape, with their rounded apices marginad, and all except the anal spot are higher than wide. These spots are widely separated. The paratypes differ slightly in the size of the spots; on the Aug. 1 specimen they are smaller, and on the July 25 specimen they are larger.

Penrosada apiculata form **curvilinea** (Weymer)

1912. Weymer, Seitz' Macrolepidoptera, 5: 248.

Type Locality.—Boqueron de Chipaque, Cord. Oriental, Colombia, 3200 m. (Fassl).

Range.—Colombia and Ecuador.

Material.—Four specimens were taken by W. J. Coxey at Huigra, Ecuador, 4000 ft., 25.VII–1.VIII.32, on the western slope; these are in the collections of the Philadelphia Academy of Natural Science. There is a single specimen of this form in the U. S. National Museum from the Dognin collection; the data given on the pin label read "Environs of Loja."

This form might easily be confused with either *leaena* or *lanassa*. From the former it may be distinguished by the irregularity of the light band on the under side of the hind wing, the regularity and sharp definition of the zigzag lines on the under side paralleling the margin, especially on the fore wing. From *lanassa* it may be distinguished by the distinct ocelli on the upper side of the hind wing, the much less uniform light band on the under side of the hind wing, and the much more acute angles in the zigzag line on the veins. I suspect that Dognin confused his specimen with *leaena* in his published list.

The male genitalia (B1682 in U. S. N. M.) are like those of *apiculata*.

The insect described as *saturata* by Weymer in Seitz' (5:249) may be a form of this species or the next. The position of the light band on the under side of the hind wings indicates that it is not *leaena*. He reports it from Colombia (Quindiu Pass) and Peru (Cuzco). Both of these stations are on the west slope of the Andes. I have not seen it from Ecuador, but the region where it should fly in Ecuador has barely been visited by entomologists. *L. keithi* Dyar seems to me to be a synonym of *saturata*. If the Colombia and Peru forms prove to be distinct, Dyar's name should be applied to the Peru form and Weymer's name to the Colombia form. The genitalia of the type of *keithi* is shown in figure WDF.

Penrosada lanassa (Felder)

Figure 1616

1867. Felder, Reise Novara, Lepidoptera, 3: 474.

Type Locality.—Bogota, Colombia (Lindig).

Range.—Colombia and Ecuador.

Material Examined.—1♂ 8.IV.39, 3200 m. (F. M. B.), Minza Chica, Tungurahua; 1♂ XI.39 (W. C.–M.), Pappallacta to Archidona, Napo-Pastaza; 1♂ XI.39 (W. C.–M.), Quito to Rio Toachi, Pichincha. I can vouch for the data on the Minza Chica specimen because I caught it,

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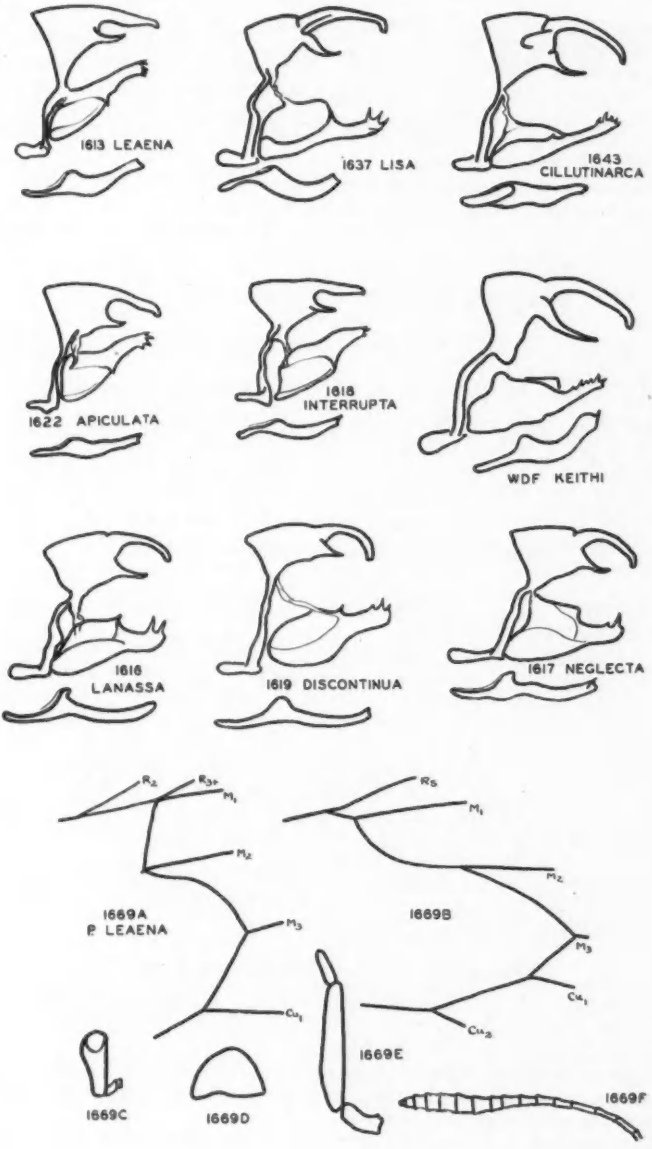
EXPLANATION OF PLATE

Genitalia and other structures of *Penrosada*. Figure 1613, *leaena* (Baños, 18.X.38, 1700 m.); 1616, *lanassa* (Minza Chica, 8.IV.39, 3200 m.); 1617, *lanassa* form *discontinua*, holotype; 1618, *apiculata* form *interrupta*, holotype; 1619, *lanassa* form *neglecta*, holotype; 1622, *apiculata* (Pan to Paute, 16.II.39, 2800 m.); 1637, *lisa* (Huancayo, Peru, *ex* Johnson, 3500 m., lot 39, A. M. N. H.); 1643, *cillutinarca* (road between Cocopunco and Pararani, Bolivia, 5,200–10,000 ft., 29.III.26, *ex* Tate, A. M. N. H.); 1669, *leaena* (Runtún, 22.XI. 38, 2800 m.: *a*—venation at the end of the cell of the fore wing, *b*—venation at the end of the cell of the hind wing, *c*—prothoracic leg, *d*—tegula, *e*—palpus, *f*—club of the antenna; WDF, *keithi*, holotype (after mss. drawing by W. D. Field).


1613 LEAENA
1637 LISA
1643
CILLUTINARCA
1622 APICULATA
1618
INTERRUPTA
WDF KEITHI
1616
LANASSA
1619 DISCONTINUA
1617 NEGLECTA
1669A
P. LEAENA
1669B
1669C
1669D
1669E
1669F

but the two obtained from Macintyre were bought in Quito from bird collectors (the Olalla's?), and each bore obviously incorrect locality data far down in the humid tropical jungle. The localities given above are the trails to the localities given on the papers enclosing the specimens.

Coxey collected four specimens at Huigra, Ecuador, 4000 ft., 20.VII–1.VIII.32, and four at Hda. Licay, above Huigra, 7000 ft., 17–29.VII.32, on the western slope. These are in the collections of the Philadelphia Academy of Natural Science.

Weymer's designation of this species as a "race" of *leaena* Hew. is incorrect on both pattern and genitalia of the males.

On the basis of pattern and genitalia the following two new forms belong to this species.

Penrosada lanassa form **discontinua** new form

Figure 1617

Holotype.—♂ (No. B1617) 8.IV.39, 3200 m. (F. M. B.), Minza Chica, Tungurahua, Ecuador.

In this form the yellowish band on the under side of the hind wings is crossed by dark brown lines on the veins, breaking the band into a series of quadrate spots that are clearly separate. The male genitalia differ slightly from those of typical *lanassa* in the line of the upper margin of the valves. In this respect the genitalia resemble those of *keithi* (fig. WDF).

Penrosada lanassa form **neglecta** new form

Figure 1619

Holotype.—♂ (No. B1619) 8.IV.39, 3200 m. (F. M. B.), Minza Chica, Tungurahua, Ecuador.

On this form there is no trace of the yellowish band across the disc of the under side of the hind wings. The discrete white spots on the upper side of the wings are similar to those in *lanassa*. The male genitalia (fig. 1619) are similar to those of *lanassa* (fig. 1616). The form *neglecta* differs from *cillutinarca* Weymer (fig. 1643), with which it might be easily confused, both in genitalia and pattern. In *cillutinarca* the uncus is proportionally longer and the aedeagus lacks the "hump" found in *lanassa* and its forms. In pattern the differences are less visible but *neglecta* lacks the submarginal ocelli that are always present on the under side of the hind wings of *cillutinarca*.

The only specimens of *cillutinarca* that I have seen are from Bolivia, taken between Cocopunco and Pararani in 1926 by Mr. G. H. H. Tate of the American Museum of Natural History.

Penrosada lisa form **reducta** new form

Holotype.—♂ (No. B1681) VIII.1911, Rio Pampaconas, Peru (Yale Peruvian Expedition, U. S. N. M.). *Paratype*: ♂ VIII.1911 (Yale Peruvian Expedition, U. S. N. M.).

This form differs from the typical form in having the orange wedge across the upper side of the hind wings reduced to a large rusty-brown area on the anal angle and margin.

The specimens of *lisa* and its probable form *reducta* that I have seen all came from central Peru. These two forms are in the American Museum of Natural History and the U. S. National Museum respectively.

A REVISION OF THE NORTH AMERICAN SPECIES BELONGING TO THE GENUS HYDROPHORIA ROBINEAU-DESVOIDY

(Diptera: Muscidae)

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Flies of the anthomyid genus *Hydrophoria* Robineau-Desvoidy occur commonly in the vicinity of woodland streams, lakes and moist terrain. Certain species, such as *H. nigerrima* Malloch, are known only through capture on higher mountain ranges, whilst a few are evidently restricted in habitat to boreal regions. The larvae, so far as is known, are aquatic. Twenty-seven species are herein recorded from North America.

The genus *Hydrophoria* is not readily defined for diagnostic purposes despite the fact that the species may be fairly readily grouped owing to their affinity. Two segregates lie within the genus, as exemplified in *Anthomyia conica* Wiedemann and *Anthomyia divisa* Meigen respectively. Schnabl and Dziedzicki (1911)[1] have applied the names *Hydrophoria* and *Acroptena* to denote these groups. The characters that I have found of value for distinguishing the genus *Hydrophoria* from allied segregates are as follows: The species lack any bristle or setae on the thoracic pteropleura as in *Emmesomyia* and *Taeniomyia sensu* Malloch, the dorsal bristle of mesopleural series is proportionately stronger than in *Neohylemyia* and most *Hylemyia*, the hind tibiae possess more bristles on the anterodorsal and posterodorsal surfaces than the normal two or three pairs present in *Pegomyia*, except in *divisa* and *proxima* where there are normally two postero-dorsal bristles. Most of the North American species are blackish including the appendages of head and thorax. Notable exceptions in this regard are *conica*, *ruralis*, *galeata*, *divisa*, *katmaiensis* (♀), *brunneifrons* (♀), where the tibiae are or may be more or less yellow. The thorax in many species is marked by three dark broad vittae, and the terminal sclerites of ovipositor are armed with short recurrent spinules except in the cases of *laticornis* and species comprising the *frontata* group. The mid tibia has a medial antero-ventral bristle except in *divisa*, *conica*, *ruralis*, and *galeata*. The following species possess hairs on the upper border of the hypopleura: *frontata*, *verticina*, *nigerrima*, *polita*, *packardi*, *brunneifrons*, *katmaiensis*, *divisa*, and also, though not invariably, in *proxima* and *laticornis*. The males of the following species possess a tuft-like growth of bristles on the lateral borders of the fourth abdominal tergum: *alaskensis*, *borealis*, *fasciculata*, *lucidiventris*, *wierzejskii*, *ambigua* Stein not Fallén.

I wish to express my acknowledgment for assistance from the following institutions in the loan of material: United States National

[1]Reference to literature cited in the synonymies is signified by date of publication.

Museum [U. S. N. M.], Division of Entomology of the Canadian Department of Agriculture [C. N. C.], University of Alberta, American Museum of Natural History [A. M. N. H.], New England Museum of Natural History [N. E. M. N. H.], Cornell University [C. U.], Oregon State College, Michigan State College, Utah Agricultural College, Montana Agricultural Experiment Station, Brigham Young University. It has also been my privilege to examine material in the private collections of Dr. D. G. Hall, Dr. A. L. Melander, Dr. F. M. Snyder, and Mr. R. E. Rieder, opportunities for which I am deeply grateful.

CRITICAL NOTES ON THE LITERATURE PERTAINING TO NORTH AMERICAN SPECIES

The earliest reference to species of the genus occurring in North America may be found in Walker's (1849) list of dipterous insects in the British Museum of Natural History, in which he described the form *Anthomyia teate* from the Hudson Bay region. Stein (1901, 1907) considered the species as apparently the same as the European form *Anthomyza brunneifrons* Zetterstedt. In 1857 Schiödte recorded the presence of *Anthomyza frontata* Zetterstedt from Greenland, a species which was later reported from the same region by Boheman (1865) under the name *Scatomyza obscura*.

In 1878 Meade[2] published notes on a collection of flies belonging to the Museum of Comparative Anatomy at Cambridge which had been sent to him by Baron Osten Sacken for purposes of identification in which the former mentioned the recognition of three species belonging to *Hydrophoria*, one being similar to *Anthomyia ambigua* Fallén. In the same year Osten Sacken,[3] furnished with this information, included the genus in his catalogue of North American Diptera, mentioning no species. Hagen[4] on the return of the collection to the Museum amplified Meade's comments but gave no additional information concerning the identity of the species.

Bigot[5] in 1885 described *Hydrophoria nigricauda* from the Rocky Mountains and *H. pictipes* and *H. calopus* from Mexico. The former species is in my opinion more properly placed in *Neohylemyia* Malloch, and the latter two, according to Stein (1919) and Séguy (1937), belong to *Taeniomyia* Stein and *Bithoracochaeta* Stein respectively. In 1896 Van der Wulp[6] employed the genus for the reception of four new Mexican species, all of which with the possible exception of *plumosa* may be regarded as belonging to *Emmesomyia* or *Taeniomyia*, as recently indicated by Van Emden[7], rather than to *Hydrophoria* of authors.

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[2]Meade, R. H. Notes on the Anthomyidae of North America. Ent. Month. Mag., (1877–1878), 14: 250–252, 1878.

[3]Osten Sacken, C. R. Catalogue of the described Diptera of North America. Misc. Coll. Smithsn. Inst., III, No. 270, p. 165, 1878.

[4]Hagen, H. A. List of N. American Anthomyidae, examined by R. H. Meade, Esq., Bradford, England. Can. Ent., 13 (3): 46, 1881.

[5]Bigot, J. M. F. Diptères nouveaux ou peu connus. 25e Part. XXXIII. Anthomyzides nouvelles. Ann. Soc. Ent. France, (1884), 6e ser., No. 4, pp. 274–277, 1885.

[6]Van der Wulp, F. M. Insecta, Diptera. Biol. Centr. Amer., 2: 332–334, 1906.

[7]Van Emden, F. I. Keys to the Muscidae of the Ethiopian Region: Scatophaginae, Anthomyiinae, Lispinae, Fanniinae. Bull. Ent. Res., 32 (3): 258, 1941.

Lundbeck (1898) in reporting on the fauna of Greenland provided fresh data concerning the distribution of *brunneifrons* and *frontata*, both of which are referred to the genus *Hylemyia*. He added *divisa* Meigen to the records from this region as a *Spilogaster*. Twenty years later, in a joint study of the land arthropods with Henriksen (1917), these species were transferred to *Hydrophoria* and *Acroptena* respectively. More recently material collected from the circumpolar regions has been studied by Malloch (1918, 1934), Collin (1923, 1924, 1931), Longstaff (1936), Carpenter and Holm (1939), in which two additional forms are recognized, namely the native species *arctica* and the European form *Anthomyza verticina* Zetterstedt.

In 1898 Stein reported the occurrence of *divisa* and *ambigua* from the United States, the latter species being represented by material from Massachusetts and Illinois. In my opinion Stein was mistaken here in his recognition of *ambigua*, and this error has given rise to the commonly accepted belief that Fallén's species occurs widely in the United States east of the Rocky Mountains. The distribution of the true *ambigua* so far as available records would indicate is confined to the western States and Alaska (Coquillett, 1900). Stein's *ambigua* in the above instance is an unnamed species. The same author (1904), from a study of exotic material in the National Museums at Berlin and Budapest included in *Hydrophoria* two North American forms which he had earlier described as *Spilogaster hilariformis* and *S. socialis*. These species belong respectively to Malloch's segregates *Dendrophaonia* and *Emmesomyia*. Only two North American species are included by Stein (1919) under *Hydrophoria* in his extensive annotated list of exotic anthomyian flies, namely *H. nigricauda* Bigot and *Anthomyia teate* Walker. The Mexican species *Hylemia tenuirostris* Van der Wulp is cited by Stein as a synonym of *nigricauda*, in which case it seems probable that Bigot's species is nearer *Neohylemyia* Malloch than to *Hydrophoria*. Stein's (1920) second large contribution to the North American fauna of Anthomyiidae contains the records of three species under *Acroptena* and one in *Hydrophoria*, of which the European forms *A. ignobilis* (Zett.) and *H. ruralis* (Meigen) are new additions.

Aldrich (1905) in cataloguing the two-winged flies of North America cited ten nominal species under *Hydrophoria*, including therein the Mexican records of Bigot and Van der Wulp. Of this number only *ambigua*, *divisa* and *teate* may be regarded as belonging to the genus as here delimited.

Malloch (1918, 1919, 1920, 1924, 1934) in a large number of contributions to the nearctic fauna has recorded the presence of nearly twenty species, of which the great majority were regarded as native forms. Keys were published to males of eighteen species and to females of thirteen. Malloch finally recognized the *Acroptena* group as apart from *Hydrophoria*, placing in the former those species possessing fine hairs on the upper anterior margin of the hypopleura, and retaining the latter name for those lacking this character. A more detailed treatment of Malloch's species may be found in the discussion of taxonomy and relationships forming the latter part of this revision.

The fauna of the different states and provinces has been compiled by Cole and Lovett (1921) for Oregon, Huckett (1924) and Leonard (1928)

for New York, Johnson (1925, 1927) for New England, Hallock and Parker (1926) for New Jersey, Brimley (1928) for North Carolina, and Strickland (1938) for Alberta. Of the New York records it may be pertinent to mention that later studies have shown that ***orientalis*** is the same species as ***Pegomyia palposa*** (Stein), and that ***flavohalterata*** has been mistakenly included. Of the Alberta fauna, the striking species ***wierzejskii*** (Mik) had been earlier recorded from Washington by Malloch (1920) as *H. elongata*. The species listed in the provincial records as ***bispinosa*** and ***occulta*** are evidently names that properly belong to the genus ***Hydrotaea***.

Séguy (1937) referred to the genus as *Hydrophoria* in "Genera Insectorum." He proceeded to distinguish the two segregates *Hydrophoria* and *Acroptena* by a series of arbitrary characters, which he concluded could scarcely be applied satisfactorily. Hence he decided to include the two segregates under one generic name. There are sixty-seven nominal species listed in the genus, of which twenty-seven are mentioned as occurring in the nearctic region, including, in my opinion, the nongeneric forms ***nigricauda*** and ***orientalis***.

In the present study twenty-seven species are recognized as occurring in North America, of which two are described as new. Of this number twelve were first recorded from Europe, one from Siberia, and fourteen from North America.

Genus **Hydrophoria** Robineau-Desvoidy

Hydrophoria Robineau-Desvoidy, Essai Myod., p. 507, 1830; Macquart, Hist. Nat. Ins., 2: 297–302, 1835; Rondani, Dipt. Ital., Prodr., 6: 12, 1877; Meade, Ent. Month. Mag., (1881–1882), 18: 101–104, 1881; Strobl, Verh. zool.-bot. Ges. Wien, 43: 242–245, 1893; Meade, Descr. List Brit. Anth., 1: 29–32, 1897; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905; Stein, Kat. Palāark. Dipt., 3: 684–687, 1907; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 135–138, 221, 1916; Henriksen and Lundbeck, Gronlands Landarthropoder, p. 639, 1917; Stein, Arch. f. Naturgesch. (1917), 83 A (1): 149, 1919; Malloch, Can. Ent., 52: 253–257, 1920; Séguy, Faune de France, 6: 140–142, 1923; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), pp. 14–16, 1924; Karl, Tierwelt Deutschlands, 13 (3): 117–119, 1928; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31, 1935; Séguy, Gen. Insect., Fasc. 205, pp. 130–135, 1937.

Zaphne Robineau-Desvoidy, Essai Myod., p. 527, 1830; Coquillett, Proc. U. S. Nat. Mus., 37: 621, 1910.

Acroptena Pokorny, Wien. Ent. Zeitg., 12 (2): 60-63, 1893; Stein, Kat. Palāark. Dipt., 3: 683, 1907; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 132–136, 221, 1916; Henriksen and Lundbeck, Gronlands Landarthropoder, p. 638, 1917; Ringdahl, Ent. Tidskr., 39 (2): 186–188, 1918; Stein, Arch. f. Naturgesch., (1917), 83 A (1): 149, 1919; Séguy, Faune de France, 6: 143–147, 1923; Karl, Tierwelt Deutschlands, 13 (3): 119–121, 1928; Malloch, Mem. Carnegie Museum, 12 (Pt. II, Sect. 4): 25, 1934; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31–32, 1935.

Anthomyia (*Hydrophoria*) Pandellé, Rev. ent. France, 19: 218–222, 1900.

Genotype.—*Anthomyia conica* Wiedemann (= *Hydrophoria tibialis* and *H. saggitariae* Rob.-Desv.) by designation of Rondani (1877).

The genus *Hydrophoria* Robineau-Desvoidy (1830) was erected for the reception of nine nominal species, none of which have since been recognized with any degree of confidence by subsequent authors. In 1840 Westwood[8] designated *Musca nigrita* Fallén as the genotype of *Hydrophoria*. Fallén's species was regarded by Macquart (1835) as identical with *Hydrophoria littoralis* Robineau-Desvoidy, the last of the species originally placed in the genus. In 1910 Coquillet designated *Musca vespertina* Fallén (not Malloch)[9] as the genotype of *Hydrophoria*, a name used in preference to *nigrita* for reasons of priority in the belief that the two species were the same. This interpretation of the species was later noted by both Stein (1907) and Séguy (1937). However in 1838 Zetterstedt had observed that the true *nigrita* of Fallén was none other than a damaged specimen of *Musca tempestiva* Fallén, a condition which he implied might be the cause for confusion concerning the identity of the species.

I have come to the opinion that the species named by Westwood as *nigrita* was probably in accordance with Macquart's views, since Westwood had cited Macquart as his authority for *Hydrophoria*. But owing to Zetterstedt's statement I am not inclined to believe that their species was Fallén's *nigrita*, though quite conceivably the same as *littoralis* and *vespertina*. In the light of such opposing evidence regarding the identity of *Musca nigrita* Fallén it seems to me advisable that any decision regarding the validity of Westwood's action for purposes of genotype fixation may well be postponed pending the results of further study.[10]

In 1877 Rondani selected *Anthomyia conica* Wiedemann to be genotype of *Hydrophoria*, a species linked by synonymy to *tibialis* (Macquart, 1835) and to *saggitariae* of the original series. This concept of the genus has been generally accepted, although in later years there has been a tendency to restrict its scope.

The genus *Zaphne* Robineau-Desvoidy (1830) has been treated as a synonym of *Hydrophoria* on the assumption that the two nominal species named in the genus were synonyms of *Anthomyia divisa* Meigen. The status of the group was revived by Coquillett (1910) in the designation of *divisa* as the genotype after considering the original forms *hylemyoidea* and *egerioidea* as conspecific. Acceptance of this synonymy seems to rest mainly on the fact that Macquart (1835) at an early date had regarded *hylemyoidea* as the same species as his *Hylemyia dispar*. With greater assurance authors have considered *dispar* to be identical with *divisa*.

In 1893 Pokorny established the monobasic genus *Acroptena* for the reception of the new form *A. simonyi*. Karl (1928) and Séguy (1937) have cited *Anthomyia divisa* Meigen as the type of *Acroptena*, a choice

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[8]Westwood, J. O. Synopsis of the genera of British flies. *In* An introduction to the modern classification of insects, II, p. 142, 1840.

[9]Ringdahl, O. Bidrag till kännedomen om flugfaunen (Diptera Brachycera) på Hallands Väderö. Ent. Tidskr., 62 (1–2): 22–23, 1941.

[10]In coming to these conclusions I should like to acknowledge the assistance of Dr. F. Van Emden, who has kindly communicated to me Mr. J. E. Collin's comments on the matter. In this, among other things, Mr. Collin has drawn my attention to Zetterstedt's explanation, of which I was not aware.

scarcely necessary in view of the monobasic character of the genus, and were it not for the fact that *divisa* had already been proposed by Coquillett as the genotype of *Zaphne*. The name *Acroptena* was early employed by Schnabl and Dziedzicki (1911) to denote those species not belonging to *Hydrophoria* in the strict sense, of which *divisa* may be regarded as one of the best known forms.

EXPLANATION OF TERMS USED IN KEYS

The distance between the eyes is measured at the narrowest width of the frons; height of cheek at its narrowest; breadth of parafacial at its widest, when viewed in profile; length of aristal hairs implies the longest. The pronotal dorsocentral setae are the first pair of longish setulae on the dorsocentral planes of mesonotum.

The first abdominal tergum is considered as terga 1+2 owing to its connate structure, the fourth visible sclerite as tergum 5, and the abdominal tuft when present on tergum 4. The basal sclerites of the hypopygium are placed immediately cephalad of tergum 9. The latter is considered the anal sclerite. The processes refer to the male copulatory appendages of sternum 5.[11] The posteroventral surface of the hind femur is considered bare when devoid of all bristles except one which may be present at the extreme base and for any that may be present in the preapical region.

KEY TO MALES OF NORTH AMERICAN HYDROPHORIA

1. Hypopleura with one or more hairs on upper margin 2
   Hypopleura bare on upper margin 12
2. Ninth tergum (anal sclerite) clothed exclusively with short uniformly developed setae which tend to become stouter mesad and caudad (ventrad), e. g., *frontata* (fig. 7) 3
   Ninth tergum clothed with diverse bristles and setae, the longest on dorsal region (cephalad), e. g., *divisa* (fig. 5) 8
3. Basal sclerites of hypopygium lightly and extensively dusted on dorsum (p. 271) ..... **verticina**
   Basal sclerites largely polished on dorsum, at most with a small dusted area at dorsocentral region 4
4. Basal sclerites of hypopygium bare, without bristles (p. 272) ..... **polita**
   Basal sclerites having bristles 5
5. Basal sclerites with a few setulae among the bristles, processes having a uniformly dense series or tuft of setulae on basal half of inner margin, outer surface of processes clothed for the greater part with fine slender setae, which are directed caudad 6
   Basal sclerites with only three or four pairs of bristles, devoid of accessory setulae, processes with a dense fringe of setulae arising near middle of inner margin, which is extended weakly basad, outer surface of processes armed with fine erect bristles that are downwardly or outwardly directed (p. 272) ..... **alpina**
6. Processes short and stoutish, rounded and broadened on apical region, inner marginal hairs situated basad as a tuft, aristal hairs barely as long as half width of third antennal segment (p. 274) ..... **frontata**
   Processes tapering apicad, inner marginal hairs extending to beyond middle as a fringe, aristal hairs at least as long as half width of third antennal segment 7

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[11]Crampton, G. C. The terminal abdominal structures of male diptera. Psyche, 48 (2-3): 79-94, 2 pls., 1941.

7. Parafrontals contiguous in front of ocellus interrupting the interfrontalia, eyes separated by diameter of anterior ocellus, costal thorn as long as *r-m* cross vein, halteres yellow (p. 275)..... **altilega**
Parafrontals narrowly separated by interfrontalia caudad, eyes separated by more than diameter of anterior ocellus, costal thorn inconspicuous, not as long as *r-m* cross vein, halteres blackish (p. 276)..... **nigerrima**
8. Aristal hairs not longer than basal diameter of arista, upper anterior border of mesopleura with a weak bristle-like seta, cerci (superior forceps) extending apicad as a needle-like process between the gonostyli (inferior forceps), e. g., fig. 17 (p. 276)..... **laticornis**
Aristal hairs about as long as width of third antennal segment, mesopleura lack a weak bristle-like seta on upper anterior border adjacent anterior notopleural bristle..... 9
9. Mid tibia with no medial anteroventral bristle, posterior notopleural bristle with a few hairs at base (p. 278)..... **divisa**
Mid tibia with a medial anteroventral bristle, posterior notopleural bristle devoid of hairs at base..... 10
10. Marginal bristles of fifth abdominal tergum weakly developed, not longer than those on ninth tergum (anal sclerite), hind tibia with two posterodorsal bristles, eyes separated by a distance about equal to width of third antennal segment, inner margin of processes with an inconspicuous fringe of short hairs (p. 279)..... **proxima**
Marginal bristles of fifth tergum longer than those on ninth tergum, eyes separated by a distance less than width of third antennal segment, processes with a conspicuous fringe of longish setulae on inner margin... 11
11. Processes bent mesad at apex, gonostyli (inferior forceps) broad and plate-like, curved inward and pointed at apex, anal cleft extending three-quarters length of ninth tergum, thus nearly dividing the sclerite in two (p. 280)..... **katmaiensis**
Processes not bent mesad at apex, gonostyli slender and geniculate, anal cleft reduced to small proportions, scarcely reaching beyond middle of sclerite (p. 282)..... **brunneifrons**
12. Tergum 4 tufted below..... 13
Tergum 4 not tufted below, at most with a dense series of longish bristles along lateral border..... 18
13. Fifth fore-tarsal segment armed with a stoutish bristle, fourth fore-tarsal segment longer than third, mid femur with posteroventral bristles scarcely longer than apical setulae, hind femur with posteroventral surface bare except for apical and basal bristles (p. 283)..... **wierzejskii**
Fifth fore-tarsal segment not armed with a stoutish bristle, second, third and fourth fore-tarsal segments successively shorter, mid femur with longish posteroventral bristles..... 14
14. Tergum 4 sharply narrowed laterad (ventrad) by infolding of integument so that lateral margin appears less than half as long as that of tergum 3.. 15
Tergum 4 not sharply narrowed laterad by infolding of integument, lateral margin of tergum 4 appears longer than half length of that of tergum 3 (p. 284)..... **borealis**
15. Longest bristles in abdominal tuft equal to or more than three-quarters length of hind tibia, prealar bristle longer than posterior notopleural bristle, aristal hairs scarcely as long as basal diameter of arista..... 16
Longest bristles of abdominal tuft not more than half length of hind tibia, prealar bristle shorter than posterior notopleural bristle..... 17
16. Tuft arising on basal third of ventral surface of abdomen (p. 286)..**lucidiventris**
Tuft arising at about middle of ventral surface of abdomen (p. 286), **alaskensis**
17. Aristal hairs fully as long as half width of third antennal segment, scutellum and mesonotum grayish pruinescent, the latter with three distinct vittae, *m-cu* cross vein markedly sinuate, directed in a plane which if extended cephalad would intersect costa at point of union with R_{2+3} (p. 287), **implicata**
Aristal hairs not as long as half width of third antennal segment, scutellum and mesonotum largely blackish and shining, with little trace of pruinescence, *m-cu* cross vein lying in a plane which if extended cephalad would intersect costa proximad of union with R_{2+3} (p. 288)..... **fasciculata**

18. Marginal bristles of fifth abdominal tergum weakly developed, not longer than those on ninth tergum, upper anterior border of mesopleura with no weak bristle-like setae (p. 279) ..... **proxima**
Marginal bristles of fifth tergum well developed, longer than those on ninth tergum, mesopleura invariably with one or more weak bristle-like setae on upper anterior border adjacent anterior notopleural bristle 19
19. Mid tibia with no medial anteroventral bristle, arista pectinate, hairs as long as width of third antennal segment, hind tibia more or less brownish tinged, paler than femora 20
Mid tibia with a medial anteroventral bristle, aristal hairs shorter than width of third antennal segment, hind tibia blackish, concolorous with femora 22
20. Prealar bristle long, calyptrae and basal region of wings densely yellowish, large species, 7–9 mm. (p. 288) ..... **conica**
Prealar bristle shorter than posterior notopleural bristle, wings and calyptrae not densely yellowish, smaller species, 6 mm 21
21. Parafacials at base of antennae as wide as breadth of third antennal segment, hind tibia with a bristle on proximal half of posterior surface, abdomen blackish (p. 290) ..... **galeata**
Parafacials narrower than breadth of third antennal segment, hind tibiae with no bristle on proximal half of posterior surface, abdomen yellowish tinged basad (p. 291) ..... **ruralis**
22. Aristal hairs scarcely longer than basal diameter of arista 23
Aristal hairs at least as long as half width of third antennal segment 24
23. Ninth tergum (anal sclerite) enlarged and subglobose, expanding dorsad above plane of tergum 5, processes devoid of longish bristles, prealar bristle as long as anterior notopleural bristle, mid tibia usually with two anterodorsal bristles (p. 292) ..... **zetterstedti**
Ninth tergum not raised above plane of tergum 5, not proportionately abnormal in size, processes armed on outer border with a few long slender bristles, prealar bristle shorter than anterior notopleural bristle, mid tibia usually with one anterodorsal bristle (p. 276) ..... **laticornis**
24. Ninth tergum appressed when viewed from above, and clothed with fine setulae which become longer and denser caudad (ventrad), middle bristles of marginal series on tergum 5 set much further from caudal margin than is the case on tergum 4, chitin along caudal border of tergum 5 extensively membranous, hind tibia with one or two short bristles on posteroventral and posterior surfaces proximad, processes devoid of bristles except basad near inner margin (p. 292) ..... **seticauda**
Ninth tergum clothed with bristles and setulae which become longer cephalad (dorsad), marginal series of bristles on terga 4 and 5 about same distance from respective margins, chitin along caudal border of tergum 5 narrowly membranous at most 25
25. Eyes separated by not more than distance between posterior ocelli exclusive, if wider costal thorn minute, not longer than breadth of costa, processes slender and armed along entire outer surface with long curling bristles and setulae directed mesad, and which become longer distad, mid tibia with no preapical mid dorsal bristle, posterior notopleural bristle bare at base (p. 294) ..... **uniformis**
Eyes separated by a distance at least equal to that between posterior ocelli, if narrower costal thorn longer than width of costa, processes broad, setulose, weakly bristled 26
26. Mid femur with posteroventral bristles uniformly short, not as long as breadth of femur where situated, anteroventral surface with no bristle basad, hind femur usually with no bristles on posteroventral surface except at extreme base and at apex, occasionally with a short bristle at middle, fore tibia with preapical anterodorsal bristle setulose (p. 295), **ignobilis**
Mid and hind femora with a series of longish posteroventral bristles exceeding in length width of femur where situated, fore tibia with a longish preapical anterodorsal bristle 27

27. Thorax with one or more pairs of weak bristle-like presutural acrosticals, setulae along cephalic border of mesonotum coarse and spinulose, dorsocentral marks of abdomen becoming conspicuously narrower caudad with each successive segment (p. 296) ..... **ambigua**
Presutural acrosticals uniformly setulose, setulae along cephalic border of mesonotum fine, dorsocentral marks on abdominal segments 3, 4 and 5 of nearly equal proportions (p. 297) ..... **flavohalterata**

KEY TO FEMALES OF NORTH AMERICAN HYDROPHORIA

1. Hypopleura with one or more setulae on upper margin 2
Hypopleura bare on upper margin 12
2. Mid tibia without medial anteroventral bristle, posterior notopleural bristle with a few setulae at base, ventral bristle of caudal pair of sternopleurals not longer than half length of dorsal bristle, (p. 278) ..... **divisa**
Mid tibia with a medial anteroventral bristle, posterior notopleural bristle bare at base, ventral bristle of caudal pair of sternopleurals longer than half length of dorsal bristle 3
3. Hind tibia with two posterodorsal bristles, presutural acrosticals in two closely placed series and slightly stronger than adjacent setulae, with few interserial setulae, marginal bristles of tergum 5 weak, the middle bristles and those on discal surface scarcely longer than adjacent setulae (p. 279), **proxima**
Hind tibia with three or more posterodorsal bristles, middle bristles of marginal series on tergum 5 well developed, presutural acrosticals in two well separated series, setulose and with numerous interserial setulae.. 4
4. Parafrontals broad and setulose, setulae as long as those on ocellar callosity, upper anterior border of mesopleura devoid of weak bristle-like setae, aristal hairs longer than basal diameter of arista 5
Parafrontals restricted in width and having at most only a few inconspicuous setulae which are not half as long as those on ocellar callosity, mesopleura with a weak bristle-like seta on upper anterior border adjacent anterior notopleural bristle, aristal hairs not as long as basal diameter of arista (p. 276) ..... **laticornis**
5. Mid and hind tibiae blackish, terminal sclerites of ovipositor devoid of fine recurrent spinules 6
Mid and hind tibiae yellowish, terminal sclerites of ovipositor armed with a few fine recurrent spinules 11
6. Mid tibia with two anterodorsal bristles, both of which are longer than greatest diameter of mid tibia (p. 271) ..... **verticina**
Mid tibia with one anterodorsal or if with two such bristles the shorter one not longer than greatest diameter of tibia 7
7. Grayish species, mesonotum and scutellum pale gray, veins yellowish brown on basal region of wings (p. 272) ..... **polita**
Blackish species, scutellum and mesonotum brownish black, veins blackish brown on basal region of wings 8
8. Frons with a loose inner series of erect slender setulae accompanying parafrontal bristles, mesonotum with coarse spinulose setulae along cephalic border (p. 276) ..... **nigerrima**
Parafrontals lacking an inner series of erect slender setulae accompanying the bristles, mesonotum with normal slender setulae along cephalic border 9
9. Aristal hairs at least as long as half width of third antennal segment, tergum 5 clothed with erect bristles and setulae of nearly equal length, marginal bristles shorter than length of tergum 5 along dorsocentral plane (p. 275) ..... **altilega**
Aristal hairs scarcely as long as half width of third antennal segment, tergum 5 clothed with diverse bristles and setulae, not of uniform character, marginal bristles as long as tergum 5 at dorsocentral plane 10
10. Knob of halteres yellow, hind femur with two preapical posterodorsal bristles (p. 272) ..... **alpina**
Knob of halteres purplish, hind femur with one preapical posterodorsal bristle (p. 274) ..... **frontata**

11. Fore tibia largely reddish yellow on proximal half, frontal vitta entirely blackish or largely reddish, caudal region being sometimes purplish tinged, veins yellowish on basal region of wings (p. 280)..... **katmaiensis**
Fore tibia largely infuscated on proximal region, frontal vitta with a reddish patch at base of antennae, blackened caudad, veins brownish on basal region of wing (p. 282)..... **brunneifrons**
12. Mid tibia with no medial anteroventral bristle, caudal pair of ocellar bristles widely divergent and directed outwards, arista pectinate..... 13
Mid tibia with a medial anteroventral bristle, caudal pair of ocellar bristles narrowly divergent and directed forward..... 15
13. Prealar bristle long, calyptrae and basal region of wings densely yellowish, ventral bristle of caudal pair of sternopleurals long and strong, large species, 7 mm. (p. 288)..... **conica**
Prealar bristle shorter than posterior notopleural bristle, calyptrae and basal region of wings hyaline, ventral bristle of caudal pair of sternopleurals short and weak, smaller species, 5 mm..... 14
14. Marginal bristles on tergum 5 finely developed, not stronger than those on disc, abdominal vitta not noticeably broadened on terga 1+2, and 3, distal half of proboscis normal in proportions (p. 290)..... **galeata**
Marginal bristles on tergum 5 robust, stronger than discal bristles, abdominal vitta broadly band-like on terga 1+2 and 3, distal half of proboscis notably shortish and stout, abdomen sometimes with trace of yellowish testaceous basad (p. 291)..... **ruralis**
15. Hind femur usually with no bristles on posteroventral surface except for normal basal and preapical bristles..... 16
Hind femur with one or more bristles on posteroventral surface in addition to basal and preapical bristles..... 20
16. Prealar bristle as long as anterior notopleural bristle, calyptrae and basal region of wings densely yellowish, mid tibia with two anterodorsal bristles, both longer than anteroventral, aristal hairs scarcely longer than aristal diameter at base (p. 292)..... **zetterstedti**
Prealar bristle shorter than anterior notopleural bristle, calyptrae and wings not densely yellowish, mid tibia with one anterodorsal bristle or if two the proximal bristle not longer than anteroventral, aristal hairs longer than basal diameter of arista..... 17
17. Abdomen and scutellum black with only slight pruinescence, costal thorn prominent and as long as humeral cross vein..... 18
Abdomen and scutellum grayish and pruinescent, costal thorn weak and inconspicuous, shorter than humeral cross vein..... 19
18. Ventral bristle of caudal pair of sternopleurals longish, nearly equal to length of dorsal bristle, presutural acrosticals with one or two pairs of fine bristle-like setae that are stronger than adjacent setulae, mesonotum with no coarse spinules along cephalic border (p. 292)..... **seticauda**
Ventral bristle of caudal pair of sternopleurals shortish, about half length of upper bristle, presutural acrosticals setulose, not stouter than adjacent setulae, mesonotum with a series of coarse erect spinules along cephalic border (p. 295)..... **ignobilis**
19. Posterior notopleural bristle with one or more setulae at base, costa and veins yellowish on basal region of wing (p. 283)..... **wierzejskii**
Posterior notopleural bristle bare at base, costa and veins brownish on basal region of wings (p. 287)..... **implicata**
20. Prealar bristle as long as anterior notopleural bristle, if slightly shorter the aristal hairs scarcely longer than aristal diameter at base..... 21
Prealar bristle shorter than anterior notopleural bristle..... 23
21. Basal region of wings and calyptrae intensively yellowish, mid tibia with two anterodorsal bristles, both as long as anteroventral bristle (p. 292), **zetterstedti**
Basal region of wings not intensively yellowish, veins at least brownish in comparison with calyptrae, mid tibia with one anterodorsal bristle, if two the proximal bristle not as long as anteroventral..... 22
22. Costal thorns proportionately longish, equal to length of humeral cross vein, ovipositor armed with fine recurrent spinules on terminal sclerites, smaller species, 5 mm. (p. 286)..... **lucidiventris** and **alaskensis**

Costal thorns proportionately short and inconspicuous, shorter than humeral cross vein, terminal sclerites of ovipositor with no recurrent spinules, larger species, 6.5 mm. (p. 276) ..... **laticornis**

23. Presutural acrosticals with one or more pairs of weak bristles 24
Presutural acrosticals setulose, with no bristle-like setae that are comparable in development to pronotal dorsocentral setae 26

24. Mesonotum and abdominal terga largely blackish and shiny, concolorous with femora, dorsocentral vitta poorly defined, scutellum almost entirely blackish (p. 292) ..... **seticauda**
Mesonotum and abdominal terga grayish, paler than femora, dorsocentral vitta well marked, scutellum with distinctive paler areas laterad of dorsocentral marking 25

25. Mid tibia with mid dorsal preapical bristle lacking, posterior notopleural bristle with no setulae near base (p. 294) ..... **uniformis**
Mid tibia with mid dorsal preapical bristle present, posterior notopleural bristle with one or more setulae near base (p. 296) ..... **ambigua**

26. Aristal hairs not longer than basal diameter of arista, terminal sclerites of ovipositor with no fine recurrent spinules (p. 276) ..... **laticornis**
Aristal hairs longer than basal diameter of arista, anal sclerites armed with fine recurrent spinules 27

27. Parafacials conspicuously narrowed ventrad when viewed in profile, width at narrowest not exceeding half that at base of antennae, posterior notopleural bristle devoid of basal setulae, mid tibia usually lacking a bristle at apex of mid dorsal surface (p. 294) ..... **uniformis**
Parafacials at most only slightly narrowed ventrad, narrowest width exceeding half that at base of antennae, posterior notopleural bristle usually with one or more setulae near base, mid tibia with a bristle at apex of mid dorsal surface 28

28. Abdominal terga conspicuously grayish pruinescent, head higher than long when viewed in profile, larger species, 6 mm. (p. 296) ..... **ambigua**
Abdominal terga black, with only trace of light pruinescence, head squarish in profile, almost as long as high, smaller species, 5 mm. 29

29. Ovipositor with dorsal sclerites entirely polished, bristles on anteroventral surface of hind femur continued basad as stoutish bristles (p. 297), **flavohalterata**
Ovipositor with caudal region of dorsal sclerites largely dull and opaque, bristles on proximal region of anteroventral surface of hind femur usually weaker and finer developed than those distad 30

30. Abdominal terga largely with shiny polished reflections, aristal hairs scarcely much longer than basal diameter of arista (p. 288) .... **fasciculata**
Abdominal terga largely with traces of pruinescence, aristal hairs at least twice as long as basal diameter of arista (p. 284) ..... **borealis**

Hydrophoria verticina (Zetterstedt)

Figures 9, 19, 42

Anthomyza verticina Zetterstedt, Insect. Lapp., p. 665, 1838.
Aricia verticina Stein, Ent. Nachr., 18 (21–22): 324, 1892.
Hydrophoria arctica Malloch, Rept. Can. Arct. Exped., 1913–16, III, Pt. C, p. 69C, 1919; Malloch, Can. Ent., 52: 254, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.
Acroptena verticina Ringdahl, K. Svensk. Vetenskap. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 84, 1931; Ringdahl, Ent. Tidskr., 53 (3): 174, 1931; Ringdahl, Opusc. entom., 4 (3–4): 145, 1939.
Hydrophoria verticina Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

Ringdahl (1939) has drawn attention to the fact that until recently *verticina* has been confused with *frontata*. Stein (1907) recorded the species as a synonym of the latter. The male of *verticina* may be distinguished from that of *frontata* by having the dorsum of the basal sclerites of the hypopygium extensively dusted (not largely polished),

the processes tapering distad (not rounded and truncate), and in common with the female has two robust anterodorsal bristles on the mid tibia.

Material Examined.—Colorado: ♀, Fall River Pass, 10,500 ft. alt., VIII.23.36. *Greenland:* ♀, Hekla Havn, VI.18.92 (Deichmann) [U. S. N. M.]. *Manitoba:* 12 ♂, 2 ♀, Churchill, VIII.2–9.37; ♂, Churchill River, 20 mi. S. of Churchill, VIII.5–6.37 (R. H. Daggy and D. G. Denning) [F. M. Snyder]. *Wyoming:* ♂, Medicine Bow, VIII. 19.36 (C. J. Sorenson) [F. M. Snyder.]

Hydrophoria polita Malloch

Hydrophoria polita Malloch, Trans. Amer. Ent. Soc., 46: 170, 1920; Malloch, Can. Ent., 52: 254, 256, 1920; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

This species belongs to the *frontata* segregate. The male may be distinguished from related forms by the absence of bristles on the basal sclerites of the hypopygium, and by their entirely polished surface. The processes when viewed in profile appear broad basad and taper rapidly distad. The aristal hairs attain a length fully equal to three-quarters of the width of the third antennal segment.

Material Examined.—Colorado: ♂, Tennessee Pass, 10,500 ft. alt., VIII.6–8.20 [A. M. N. H.]. *Montana:* ♂, Georgestown Lake, VII. 31.23 (A. L. Melander).

Hydrophoria alpina new species

Male.—Black, similar in appearance and bristling to *frontata*, parafacials and cheeks densely pruinescent, basal sclerites of hypopygium entirely polished, wings faintly tinged, calyptrae white, halteres yellow, with trace of purplish tinge.

Interfrontalia complete to ocellus, longest hairs of arista about twice as long as basal diameter of arista, basal sclerites of hypopygium with three or four pairs of bristles and devoid of additional setulae, abdominal sterna 1 to 4 broad and densely setulose, processes truncate at apex and curved inward, armed at middle of inner margin with a loose tuft of longish setulae, the latter extending basad in a sparse series, outer surface clothed with fine erect bristles that are directed outward and ventrad. Mid tibia with one medial anterodorsal bristle, hind femur with bristles on proximal half of antero- and posteroventral surfaces noticeably finer than those distad, each series becoming denser and confused owing to the presence of additional erect longish setulae on proximal region.

Female.—Cheeks about half as high as height of eye, parafrontals densely brownish infuscated, and with only slight trace of shiny

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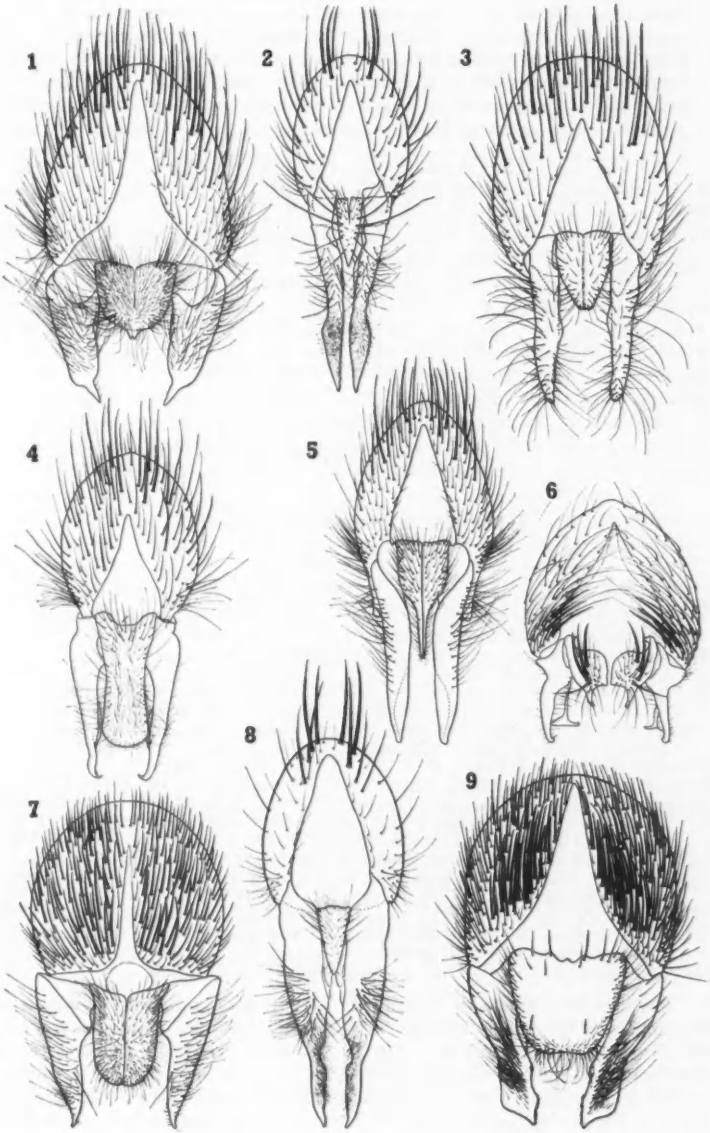
EXPLANATION OF PLATE I

Dorsal (caudal) aspect of male copulatory appendages. Fig. 1. *Hydrophoria katmaiensis* Malloch. 2. *H. conica* (Wiedemann). 3. *H. proxima* Malloch. 4. *H. brunneifrons* (Zetterstedt). 5. *H. divisa* (Meigen). 6. *H. seticauda* Malloch. 7. *H. frontata* (Zetterstedt). 8. *H. ruralis* (Meigen). 9. *H. verticina* (Zetterstedt).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reflections; abdomen with distinct pale grayish pruinescence, paler than mesonotum; parafacials viewed from above with a broad pruinescent fascia at base of antennae, in width at least equal to that of third antennal segment; fore tibia with a robust apical posterodorsal bristle, mid tibia with or without a weaker bristle basad of anterodorsal, hind femur with a second preapical posterodorsal bristle, posteroventral series of bristles extending to apex. Length 6 mm.

Holotype, ♂, Mt. Washington, New Hampshire, no date, (Mrs. A. T. Slosson) [N. E. M. N. H.]. *Allotype*, Mt. Washington, Alpine Garden, New Hampshire, VIII. 16. 16 (C. W. Johnson) [N. E. M. N. H.]. Paratypes, 2 ♀, White Mts., New Hampshire; ♀, Mt. Washington, New Hampshire, no dates, (Morrison) [U. S. N. M.].

The type specimen has Malloch's label bearing the name *Hydrophoria arctica* Mall., and as such the species has been recorded in Johnson's (1925) list of New England diptera. Later Malloch (1934) regarded *arctica* as probably identical with *frontata*. I have considered this specimen as well as others from the vicinity of Mt. Washington as distinct from those representing *frontata* on the basis of differences in the bristling of the processes and the basal sclerites of hypopygium, as indicated in the key to males. In both sexes of *alpina* the cheeks are slightly broader than in *frontata* and the halteres are invariably yellow.

Hydrophoria frontata (Zetterstedt)

Figures 7, 23, 41

Anthomyza frontata Zetterstedt, Insect. Lapp., p. 669, 1838.
Aricia frontata Zetterstedt, Dipt. Scand., 4: 1453, 1845; Holmgren, K. Vet. Akad. Handl., 8 (5): 33, 1869; Siebke, Enum. Insect. Norveg., 4: 107, 1877; Stein, Ent. Nachr., 18 (21–22): 324, 1892.
Anthomyia frontata Staeger, Krøyer's Naturhist. Tidskr., n. ser. I, p. 363, 1845; Schiödte, Naturhist, Tillaeg til Rink., p. 69, 1857.
Scatomyza obscura Boheman, Oefv. K. Vet. Akad. Förhandl., 22: 573, 1865.
Hylemyia frontata Osten Sacken, Smithsn. Misc. Coll., 3: 167, 1878; Lundbeck, Vidensk. Medd. Naturh. Foren. Kbhvn., 1: 313, 1898; Aldrich, Misc. Coll. Smithson. Inst., 46 (1444): 552, 1905.
Hylemyia spiniclunis Pandellé, Rev. ent. France, 18: 220, 1900.
Hydrophoria sopulicauda Strobl, Mitt. Ver. Steiermark, 46: 45, 168, 1910.
Acroptena frontata Henriksen and Lundbeck, Grönlands Landarthropoder, p. 638, 1917; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Collin, Ann. Mag. Nat. Hist., ser. 9, 11: 117, 1923; Collin, Ann. Mag. Nat. Hist., ser. 9, 14: 201, 205, 1924; Ringdahl, Trömso Museums Arshefter, (1926), 49 (3): 35, 1928; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 83, 1931; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Ringdahl, Skrift. om Svalbard og Ishavet, No. 53, p. 16, 1933; Longstaff, Ann. Mag. Nat. Hist., ser. 10, 18: 532, 1936; Carpenter and Holm, Ann. Mag. Nat. Hist., ser. 11, 3: 71, 1939; Ringdahl, Opusc. entom., 4 (3–4): 141, 1939.
Hydrophoria frontata Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

The species *frontata* is typical of a group within the genus which in the male has the ninth tergum (anal sclerite) clothed with a characteristic vestiture of short setae. In fact it seems that the name *frontata* has been used mistakenly in much of the literature for species belonging to this group, largely on account of the possession of this striking character in the males (Séguy 1937). This vestiture may be weak or stout,

dense or sparse, according to species, but conforming to a general distinctive pattern, e. g., in *frontata, verticina, arctica, polita, nigerrima, packardi, alpina,* the European form *Acroptena simonyi* Pokorny and the Siberian species *A. tundrica* Schnabl. The male of *frontata* has the processes short and stout, blunt and rounded at the apex, with a few weak setulose bristles directed apicad, and having a dense tuft-like series of fine setulae on the basal region of the inner margin. The basal sclerites of the hypopygium are polished except for a trace of pruinescence on the dorsocentral plane. In both sexes the aristal hairs are about equal to twice the basal diameter of the arista, and the knobs of the halteres are invariably purplish, not black as is typical of *nigerrima.*

Material Examined.—Baffin Island: 4 ♂, ♀, Clyde River, IX.15.35 (W. J. Brown) [C. N. C.]. *Greenland:* ♂, Hekla Havn, August 1891, ♀, same locality, VI.11.92, (Deichmann); ♀, Fiskenas, VII.1.89 (Lundbeck) [U. S. N. M.].

Hydrophoria altilega new species

Male.—Similar in habitus to *verticina,* but differing in having basal sclerites of hypopygium almost entirely polished, bristles of ninth tergum less stiffly formed, cerci cordate and densely setulose, processes of fifth sternum tapered distad and fringed along greater part of inner margin with a dense series of setulae. Eyes separated by a distance comparable to diameter of anterior ocellus, parafrontals contiguous caudad; parafrontal, vibrissal and genal bristles robust, aristal hairs fully as long as half width of third antennal segment. Prealar bristle short, sternopleurals arranged 2 : 2, hypopleura with hairs on upper margin. Mid tibia with two anterodorsal bristles in type. Costal thorn as long as *m-cu* cross vein, halteres yellow.

Female.—Parafrontals broad and densely setulose, fifth abdominal tergum with discal bristles and setulae less differentiated than in *verticina,* marginal bristles weakly developed. Terminal sclerites of ovipositor without recurrent spinules. Mid tibia with one anterodorsal bristle. Halteres purplish tinged. Length 7 mm.

Holotype, ♂, Hedley, British Columbia, VIII.29.23 (C. B. D. Garrett) [C. N. C.]. *Allotype,* ♀, Trail Ridge Pass, Colorado, 12,100 ft. alt., VIII.23.36 (F. M. Snyder) [C. N. C.].

Until recently I had regarded this species as identical with Malloch's *arctica,* but Mr. Brooks of the Division of Entomology at Ottawa, who has kindly compared specimens with type of *arctica,* has informed me that *arctica* agrees in all essential respects with *verticina,* even to the pollinose character of the basal sclerites of the hypopygium, which is not to be inferred from the description of *arctica.* In the male of *altilega* the basal sclerites of the hypogpyium are largely polished across the dorsum, and the bristles on the anal sclerite are less coarsely developed than in *verticina*; the cerci are cordate and densely setulose, not quadrate and largely bare as in *verticina.* In the female of *altilega* the bristles and setulae of the fifth abdominal tergum are less diverse in character, and are erect.

Hydrophoria nigerrima Malloch

Hydrophoria nigerrima Malloch, Trans. Amer. Ent. Soc., 46: 169, 1920; Malloch, Can. Ent., 52: 253, 255, 1920; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species belongs to the *frontata* segregate. In typical specimens the knobs of the halteres are black (not purplish), and the abdomen is deep black and almost devoid of pruinescence. The longest hairs of the arista are over half as long as the width of the third antennal segment, whereas in *frontata* and *verticina* these are scarcely equal to half the width of the third antennal segment. In *nigerrima* the parafrontal bristles are accompanied by an inner series of noticeably long fine setulae, and in the male the processes taper distad, not being blunt or rounded as in *frontata*.

Material Examined.—Washington: ♂, ♀, Mt. Rainier, 7,000–9,000 ft. alt., on snow, August 1917 (A. L. Melander), holotype and allotype [U. S. N. M.]. ♀, same locality and data as for holotype, paratype [Mont. Exp. Station]. ♂, ♀, Mt. Rainier, Paradise Park, August 1917, paratypes, (A. L. Melander).

Hydrophoria laticornis (Ringdahl)

Figures 17, 28, 51

Acroptena laticornis Ringdahl, Ent. Tidskr., 37 (3–4): 236, 1916; Ringdahl, Ent. Tidskr., 39 (2): 188, 1918; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

Hydrophoria congrua Malloch, Ohio Jour. Sci., 20 (7): 271, 1920; Malloch, Can. Ent., 52: 255, 1920; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

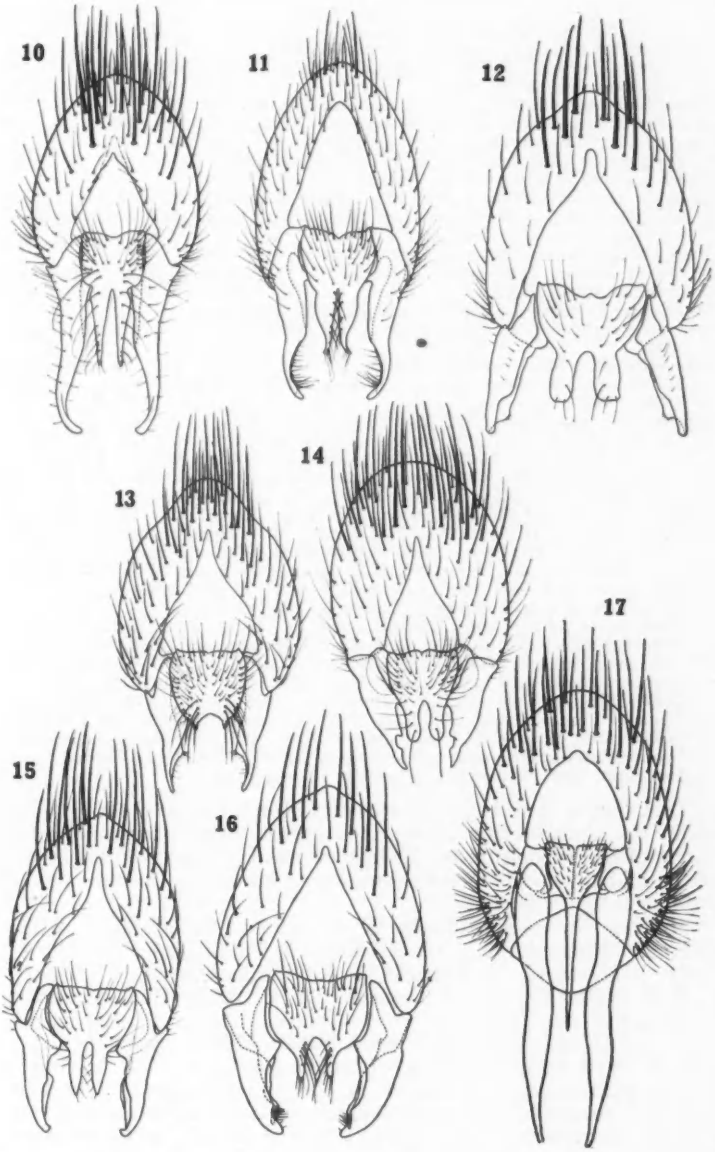
Hydrophoria laticornis Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species has the arista minutely haired, nearly bare as in *zetterstedti*, from which it may be distinguished by the slightly shorter prealar bristle and in having only one anterodorsal bristle on the mid tibia. In the male of *laticornis* the cerci (superior forceps) are prolonged as a firm needle-like process between the gonostyli (inferior forceps), and the processes bear a few significant longish bristles on the outer surface. In the female the anal palpi of the ovipositor are devoid of spinules, and not uncommonly the mid femur has a stoutish bristle toward the base of the anteroventral surface. In both sexes I have found occasional specimens with a single hair on the upper margin of the hypopleura.

Material Examined.—Alaska: ♂, Anchorage, VI.6.17 (J. S. Hine). *Alberta:* ♂, 2 ♀, Elk Island, V.16.37 (E. H. Strickland); ♀, Banff, VI.3.22, ♀, same locality, VI.1.22 (C. B. D. Garrett) [C. N. C.]. *Manitoba:* ♂, Aweme, V.27.24 (N. Criddle). *Minnesota:* ♂, Itasca Park, V.24.28, *ex* larch sawfly cocoons, (L. W. Orr). *Ontario:* 3 ♀, Low Bush, Lake Abitibi, VI.4–7.25 (N. K. Bigelow); ♀, Miners' Bay, V.26.27 (F. P. Ide).

EXPLANATION OF PLATE II

Dorsal (caudal) aspect of male copulatory appendages. Fig. 10. *Hydrophoria ambigua* (Fallén). 11. *H. wierzejskii* (Mik). 12. *H. ignobilis* (Zetterstedt). 13. *H. borealis* Malloch. 14. *H. zetterstedti* (Ringdahl). 15. *H. lucidiventris* (Zetterstedt). 16. *H. fasciculata* (Schnabl). 17. *H. laticornis* (Ringdahl).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Hydrophoria divisa (Meigen)

Figures 5, 30, 48

Anthomyia divisa Meigen, Syst. Beschr., 5: 99, 1826.
Hydrophoria nymphiae Robineau-Desvoidy, Essai Myod., 504, 1830; Macquart, Hist. Nat. Ins., 2: 300, 1835.
Hydrophoria trapae Robineau-Desvoidy, Essai Myod., 505, 1830.
Hydrophoria nymphaeicola Robineau-Desvoidy, Essai Myod., 506, 1830.
Zaphne hylemyoidea Robineau-Desvoidy, Essai Myod., 527, 1830.
Zaphne egerioidea Robineau-Desvoidy, Essai Myod., 527, 1830.
Hylemyia dispar Macquart, Hist. Nat. Ins., 2: 317, 1835.
Hylemyia divisa Meigen, Syst. Beschr., 7: 315, 1838; Meade, Ent. Month. Mag., 18: 102, 1881; Meade, Descr. List Brit. Anth., 1: 30, 1897; Pandellé, Rev. ent. France, 18: 215, 1899.
Aricia ambigua Zetterstedt p. p., Dipt. Scand., 4: 1415, 1845.
Anthomyza coronata Zetterstedt, Dipt. Scand., 4: 1658, 1845; Zetterstedt, Dipt. Scand., 14: 6275, 1860.
Aricia divisa Zetterstedt, Dipt. Scand., 12: 4723, 1855.
Hylemyia coronata Schiner, Faun. Austr., 1: 631, 1862; Bidenk, Ent. Tidskr., 13: 243, 1892.
Spilogaster divisa Mik, Verh. zool.-bot. Ges. Wien, 17: 422, 1867; Neuhaus, Dipt. March., p. 215, 1886; Lundbeck, Vidensk. Medd. Naturh. Foren. Kbhvn., 1: 309, 1898.
Hydrophoria divisa Meade, Ent. Month. Mag., 18: 102, 1881; Stein, Ent. Nachr., 14 (24): 376, 1888; Strobl, Verh. zool.-bot. Ges. Wien, 18: 243, 1893; Stein, Berl. Ent. Zeitschr., (1897), 42 (3–4): 208, 1898; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905; Stein, Kat. Paläark. Dipt., 3: 685, 1907; Smith, Ann. Rept. N. J. State Museum 1909, p. 791, 1910; Malloch, Trans. Amer. Ent. Soc., 44: 297, 1918; Malloch, Can. Ent., 52: 254, 256, 1920; Cole and Lovett, Proc. Cal. Acad. Sci., 11 (15): 312, 1921; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 15, 1924; Johnson, Insect Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.
Anthomyza dignota Bidenk, Entom. Tidskr., 11: 199, 1890.
Acroptena divisa Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 103, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1915; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 134, 1916; Henriksen and Lundbeck, Grönlands Landarthropoder, p. 639, 1917; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Séguy, Faune de France, 6: 146, 1923; Karl, Tierwelt Deutschlands, 13 (3): 120, 1928; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 84, 1931; Ringdahl, K. Svensk. Vetensakad. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935.

This species is widely distributed in North America. It may be readily distinguished from among those species with hairs on the upper margin of the hypopleura by the lack of a medial anteroventral bristle on the mid tibia and by the possession of setulae at the base of the posterior notopleural bristle.

Material Examined.—Alaska: ♂, Savonoski, Naknek Lake, VIII. 1.19; ♂, Katmai, no date, (J. S. Hine); ♀, Fairbanks, VII.3.21; ♀, Healy, VII.7.21 (J. M. Aldrich) [U. S. N. M.]. *Alberta:* ♀, Brooks, VI.8.23 (Walter Carter); ♂, Cypress Hills, VI.23.39 (W. S. McLeod); ♂, Medicine Hat, VIII.8.39; ♂, ♀, Tofield, V.22.23; ♂, Elk Island, VIII.4.23 (E. H. Strickland) [Univ. Alberta]. 4 ♂, Cooking Lake, VIII.16.36 (F. O. Morrison); 3 ♀, Lethbridge, VI. 6.23 (H. E. Gray); ♀, Waterton Lakes, VIII.29.26 (N. Criddle); ♂, Banff, VIII.8.22 (C. B. D. Garrett) [C. N. C.]. *British Columbia:* ♂, Oliver, VIII.16.23 (C. B. D. Garrett); ♂, Vernon, IX.21.27 (I. J. Ward); ♀, Crows Nest, VII.26.26 (A. A. Dennys) [C. N. C.]. ♂, South Fork Creek, VIII.11.–; ♀, Kaslo, VIII.3.– (R. P. Currie) [U. S. N. M.]. *California:* ♂, Orick,

VI.22.39; 2 ♂, Junction, IX.14.39 (G. F. Knowlton) [Utah Agr. Col.]. ♀, Tule Lake Refuge, Siskiyou County, 4,150 ft. alt., VII.1.37 (Bolinger-Jewett) [Ore. State Col.]. *Colorado:* ♂, Divide, VII.19.37 (M. & B. James); ♂, ♀, Cuchara, 8,000 ft. alt., VIII.7.40 (F. M. Snyder); ♀, Grand Lake, IX.–.26 (T. D. A. Cockerell); ♂, Ester Park, VIII.24.40 (G. F. Knowlton & W. P. Nye) [Utah Agr. Col.]. ♀, Tennessee Pass, VII.25.17 (J. M. Aldrich) [U. S. N. M.]. *Idaho:* 5 ♀, Roswell, no date; ♂, Yale, Latah County, VII.28.27; ♀, Moscow, VI.6.12 (J. M. Aldrich) [U. S. N. M.]. ♂, Thousand Springs, IX.19.38 (G. F. Knowlton) [Utah Agr. Col.]. *Iowa:* ♂, Ames, VI.5.27 (G. Hendrickson) [Iowa State Col.]. *Kansas:* ♂, ♀, Stafford County, IV.29.34 (C. W. Sabrosky) [Mich. State Col.]. *Manitoba:* ♂, Churchill, VIII.2–9.37 (D. G. Denning); ♂, Churchill River, 20 mi. S. of Churchill, VIII.5–6.37 (R. H. Daggy) [F. M. Snyder]. *Minnesota:* ♀, Cook County, Cascade River near Lake Superior, VIII.11.29 (C. T. Schmidt) [F. M. Snyder]. *Missouri:* 2 ♀, Atherton, V.15.16 (J. M. Aldrich) [U. S. N. M.]. *Montana:* ♂, Summit Station, 5,200 ft. alt., VII.25.– (J. M. Aldrich) [U. S. N. M.]. *New Jersey:* ♂, Riverton, VI.26.23 (H. C. Hallock). *New York:* ♂, Herkimer, VIII.8.21 (M. D. Leonard). ♂, Ithaca, V.17.13. ♂, Canton, VII.27.31 (J. M. Aldrich) [U. S. N. M.]. *Oregon:* ♂, Lebanon, V.27.31 (J. Wilcox); ♀, Corvallis, VI.3.31. 4 ♂, 3 ♀, Zumwalt, Wallowa County, VIII.3.41; ♀, Whitney, Baker County, VIII.6.41 (M. & R. E. Rieder). *Quebec:* ♂, St. Anne de Bellevue, VIII.26.18 (Macdonald College). *Saskatchewan:* 2 ♂, Regina, VII.5.04 (T. N. Willing) [U. S. N. M.]. *South Dakota:* ♀, Brookings, VII.16.19 (H. C. Severin) [Ohio State Museum]. 3 ♂, 3 ♀, Pringle, VII.15.24; ♂, Hot Springs, VII.13.24; ♂, ♀, Spearfish, VII.30.24; ♂, Custer, VII.17.24; 2 ♀, Martin, VII.7.24 [South Dakota State Col.]. *Utah:* ♂, Utah Lake, east side, (Vasco M. Tanner); ♂, Spanish Fork, no date [Brigham Young Univ.], ♂, Hatch, IX.14.39; ♀, Corinne, III.24.34; ♀, Loa, IX.11.38; 2 ♀, Escalan Junction, IX.11.38; ♀, Fremont, IX.8.38; ♀, Gunnison, V.28.38 (G. F. Knowlton); ♂, Hooper, IX.1.37 (D. E. Hardy) [Utah Agr. Col.]. ♂, Soldier Summit, 7,454 ft. alt., VII.6.– (J. M. Aldrich) [U. S. N. M.]. *Washington:* ♂, ♀, Lake Paha, IX.20.20; ♂, Medical Lake, VII.14.20; ♀, Ritzville, VI.16.20; ♀, Stratford, IX.4.20 (R. C. Shannon). ♀, Bellingham, V.31.17 (H. G. Dyar); ♀, Calfax, VII.4.12; ♂, 2 ♀, Friday Harbor, VII.6.05 (J. M. Aldrich) [U. S. N. M.]. *Wisconsin:* ♀, Dane County, V.27.36; ♀, Columbia County, V.10.36; ♂, ♀, Madison, V.15.36 (F. M. Snyder). *Wyoming:* ♂, Evanston, VII.17.40 (G. F. Knowlton and F. C. Harmston) [Utah Agr. Col.]. ♂, Black Sands Basin, Yellowstone National Park, no date, (Vasco M. Tanner) [Brigham Young Univ.]. *Yukon Territory:* 2 ♂, White Horse, VI.20.19 (H. G. Dyar) [U. S. N. M.].

Hydrophoria proxima Malloch

Figures 3, 31, 49

Hydrophoria proxima Malloch, Trans. Amer. Ent. Soc., 46: 171, 1920; Malloch, Can. Ent., 52: 254, 256, 1920; Johnson, Occ. Pap. Boston Soc. Nat. Hist., 7: 233, 1925; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Johnson, Insect. Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

This species usually has a single fine hair on the upper margin of the hypopleura. In case this character may appear to be absent and to ensure the recognition of the species I have included it under both captions in the keys. In the male the eyes are separated by about the width of the third antennal segment, the processes are broad when viewed in profile and are devoid of any dense fringe of longish setulae on the inner margin, when viewed from below the apical region appears to taper and curl inward, the outer surface possesses one or two longish bristles. The fifth tergum has very weakly developed marginal bristles, the gonostyli (inferior forceps) are yellowish, slender and curved slightly at apex, clothed on the entire outer surface with long curling setulae.

In the female the anterior surface of the fore femur has one or more stoutish median setulae, the anal palpi have recurrent spinules, the parafrontals are not as broad nor as densely setulose as in ***brunneifrons***. The female, like the male, has no weak bristle-like setae on the upper anterior border of the mesopleura adjacent to the anterior notopleural bristle, also in both sexes there are usually only two bristles on the posterodorsal surface of the hind tibia, and only one bristle on the posteroventral surface of the hind femur. The arista is long-haired, and the tibiae are black.

Ringdahl[12] has apparently described a closely allied species in *Acroptena separata* from northern Sweden, which may eventually be found to be identical with ***proxima***.

Material Examined.—*Alaska:* 2 ♂, Savonoski, Naknek Lake, June 1919; 2 ♂, same locality, VIII.1.19 (J. S. Hine). *Maine:* ♂, Princeton, VII.12.09 [U. S. N. M.]. ♀, Bar Harbor, VII.11.23. *Ontario:* ♂, Waubamick, VI.15.– (H. S. Parish). *Washington:* ♀, Spokane, VIII. 28.11 [U. S. N. M.].

Hydrophoria katmaiensis Malloch

Figures 1, 18, 46

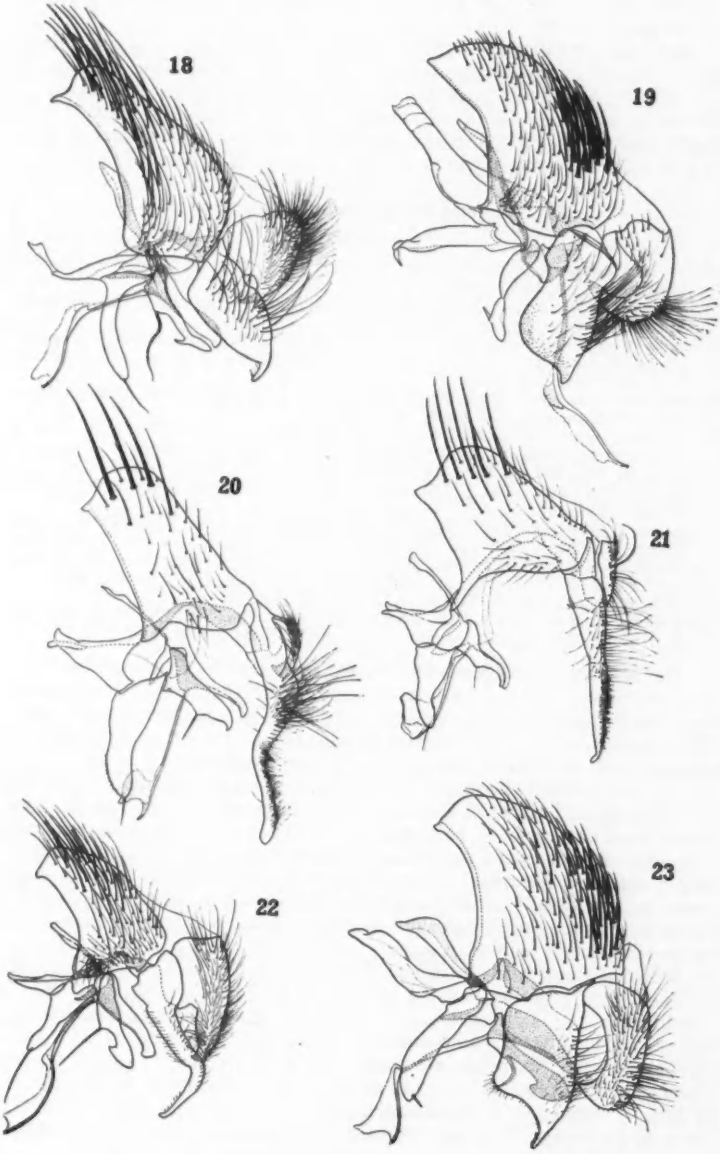
Hydrophoria katmaiensis Malloch, Trans. Amer. Ent. Soc., 46: 170, 1920; Malloch, Can. Ent., 52: 254, 1920; Séguy, Gen. Insect., Fasc., 205, p. 133, 1937.
Acroptena kamtchatica Ringdahl, Ark. Zool., 21 A (20): 8, 1930.
Hydrophoria kamtchatica Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species is closely allied to ***brunneifrons***, from which it may be distinguished as cited in the keys. In the male of ***katmaiensis*** the apical region of the processes appears bent or curled inward, and the gonostyli (inferior forceps) are broad, curved slightly inward at the apex, and terminate in a short digitate process. The parafacials of the male in profile are slightly narrower and the hairs of the arista in both sexes are scarcely as long as those of ***brunneifrons***. In male specimens of ***katmaiensis*** the color of the mid and hind tibiae may range from yellowish

[12]Ringdahl, O. Neue skandinavische Dipteren, Ent. Tidskr., 41 (1): 30, 1920.

EXPLANATION OF PLATE III

Lateral aspect of male copulatory appendages. Fig. 18. *Hydrophoria katmaiensis* Malloch. 19. *H. verticina* (Zetterstedt). 20. *H. ruralis* (Meigen). 21. *H. conica* (Wiedemann). 22. *H. brunneifrons* (Zetterstedt). 23. *H. frontata* (Zetterstedt).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to brownish, also the calyptrae and its hairs may be deeply infuscated or not so tinged.

Material Examined.—Alaska: 3 ♂, ♀, Savonoski, Naknek Lake, July 1919; ♂, Yakutat, no date, (J. S. Hine). *Manitoba:* ♀, Aweme, V.3.24 (N. Criddle) [C. N. C.]. 3 ♂, Churchill River, 20 mi. S. of Churchill, VIII.5–6.37 (D. G. Denning); 2 ♀, Churchill, VIII.2–9.37 (R. H. Daggy) [F. M. Snyder]. *Ontario:* ♂, Low Bush, Lake Abitibi, VII.27.25; ♀, same locality, VI.7.25 (N. K. Bigelow) [C. N. C.].

Hydrophoria brunneifrons (Zetterstedt)

Figures 4, 22, 50

Anthomyza brunneifrons Zetterstedt, Insect. Lapp., p. 690, 1838; Zetterstedt, Dipt. Scand., 4: 1660, 1845.

Anthomyia teate Walker, List Dipt. Ins. Brit. Museum, 4: 931, 1849; Osten Sacken, Misc. Coll. Smithsn. Inst., 3: 169, 1878.

Hylemyia brunneifrons Stein, Ent. Nachr., 18 (20–21): 330, 1892; Lundbeck, Vidensk. Medd. Naturh. Foren. Kbhvn., 1: 313, 1898; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 552, 1905.

Hydrophoria teate Stein, Zeitschr. Hymn. Dipt., 1 (4): 213, 1901; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905.

Hydrophoria brunneifrons Stein, Kat. Palāark. Dipt., 3: 684, 1907; Stein, Arch. f. Naturgesch., (1915) 81 A (10): 137, 1916; Henriksen and Lundbeck, Grönlands Landarthropoder, p. 639, 1917; Huckett, Can. Ent., 66: 140, 1934; Séguy, Gen. Insect., Fasc., 205, p. 132, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

Acroptena brunneifrons Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 84, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31, 1935; Ringdahl, Opusc. Entom., 4 (3–4): 140, 1939.

Hydrophoria occidentalis Malloch, Trans. Amer. Ent. Soc., 46: 170, 1920; Malloch, Can. Ent., 52: 254, 1920; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

The species ***brunneifrons*** and ***katmaiensis*** possess many of the characters common to the ***frontata*** segregate, but they differ superficially from the latter in being paler and more heavily pruinescent. In males of both species the ninth tergum (anal sclerite) is clothed with diverse bristles, and in females the anal palpi possess recurrent spinules. In common with ***divisa*** the mid and hind tibiae of males tend to be brownish to yellowish and those of females yellowish in contrast to the blackish tibiae in closely related segregates. In the male of ***brunneifrons*** the processes are not flexed inward at apex, and the anal sclerite is not so deeply cleft by the membranous area as in ***katmaiensis***. The series of coarsely developed median setulae on the anterior surface of the fore femur may or may not be evident in ***brunneifrons***, a character that seems to be constant in related species.

Material Examined.—Alberta: ♂, Banff, VI.21.22 (C. B. D. Garrett) [C. N. C.]. ♂, Wabamun, VI.27.36; ♀, Edmonton, V.1.24 (E. H. Strickland). ♀, Lethbridge, VI.6.23 (H. E. Gray). *Greenland:* ♀, Rödeg, VIII.17.92 (Deichmann) [U. S. N. M.]. *Idaho:* ♂, Paris, June 1926 (Vasco M. Tanner). *Nevada:* 2 ♂, 2 ♀, Wells, VI.20.27 (J. M. Aldrich); ♂, Wells, VII.12.11, holotype of *occidentalis* Mall. [U. S. N. M.]. *Ontario:* ♂, Waubamick, VI.–.15 (H. S. Parish) [A. L. Melander]. *Oregon:* 2 ♀, Crater Lake Park, near headquarters, 64–6600 ft. alt., VIII.29.30. ♀, Gold Beach, VII.12.25 (H. A. Scullen). ♂,

near Crane, VI.28.22 (W. J. Chamberlin). ♀, Hart Mt., Lake County, 7,000 ft. alt., VIII.2.32 (D. K. Frewing). 3 ♀, Breitenbush Lake, Marion County, VI.23.40. ♀, Rainier, VIII.7.36 (R. E. Rieder). ♀, Zumwalt, Wallowa County, VIII.3.41 (M. and R. E. Rieder). *Utah:* ♂, Clinton, V.25.39; ♀, Kanesville, V.15.37; ♂, Huntsville, VI.12.37; ♂, ♀, Loa, IX.8.38; ♂, Bothwell, VI.22.38; ♀, Juab, meadow, V.24.38; ♂, Alton, IX.14.39; ♂, Benson, May 1939; ♂, Plain City, V.10.39; ♂, Woodruff, VII.5.35; ♀, Hooper, V.8.31 (all G. F. Knowlton). 3 ♂, ♀, Brigham, VI.10.38 (Knowlton, Hardy, Stains). ♀, Logan Canyon, VII.26.39 (Kye and Stains). ♀, Tremonton, X.10.34 (C. J. Sorenson). ♀, Smithfield, VII.7.37 (Smith and Harmston). ♂, Daniels, VI.28.40 (Knowlton and Harmston). 5 ♀, Far West, II.7.34 (W. L. Thomas). ♂, Paradise, 1934 (O. S. Lee). ♀, Promontory Point, VII.–.11 (J. M. Aldrich) [U. S. N. M.]. *Washington:* ♀, Loon Lake, V.16.24; ♀, Orcas Island, above Mt. Lake, VIII.16.25 (A. L. Melander).

Hydrophoria wierzejskii (Mik)

Figures 11, 32, 43

Spilogaster wierzejskii Mik, Verh. zool.-bot. Ges. Wien, 17: 420, 1867.

Hydrophoria wierzejskii Pandellé, Rev. ent. France, 18: 219, 1899; Stein, Kat. Palāark. Dipt., 3: 687, 1907; Séguy, Gen. Insect., Fasc. 205, p. 135, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

Acroptena wierzejskii Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 103, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 135, 1916; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Séguy, Faune de France, 6: 147, 1923; Karl, Tierwelt Deutschlands, 13 (3): 120, 1928; Collin, Ent. Month. Mag., 66: 227, 1930.

Hydrophoria elongata Malloch, Trans. Amer. Ent. Soc., 46: 172, 1920; Malloch, Can. Ent., 52: 255, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

Males of this species may be readily recognized by the peculiar character of the fore tarsi, as indicated in the key, and by the abnormally slender mid and hind tarsi, the segments of which with the exception of the fifth are laterally compressed. The abdominal tuft is not conspicuous, the fifth abdominal sternum is polished and almost bare except for an inner marginal fringe, and the processes taper appreciably apicad. The female closely resembles that of *ambigua* Stein not Fallén.

In both sexes of *wierzejskii* there are weak bristles in the presutural acrostical series (as is also sometimes present in Stein's *ambigua*), the posteroventral surface of the hind femur is bare, that of the mid femur has only a few weak bristles which are scarcely longer than the apical posteroventral setae, the posterior notopleural bristle has one or more setulae at the base. Further, in the female the wings are yellowish basally, and there may be a weaker bristle developed basad of the medial anterodorsal bristle on mid tibia.

Material Examined.—Alberta: ♂, Banff, VIII.18.22 (C. B. D. Garrett); ♀, Lethbridge, VIII.4.24 (H. L. Seamans) [C. N. C.]. ♂, ♀, Cooking Lake, VII.25.37 (F. O. Morrison) [Univ. Alberta]. ♀, Bilby, VII.28.24 (Owen Bryant). *British Columbia:* ♂, Agassiz, VII.29.26 (H. H. Ross). ♀, Minnie Lake, VII.25.25 (N. Criddle). *Colorado:* ♀, Rogger, VIII.31.38; ♂, Walden, 8,500 ft. alt., IX.1.38 (C. L. Fluke)

[F. M. Snyder]. ♂, ♀, Grand Lake, IX.–.26 (T. D. A. Cockerell). ♀, Platte Canyon, Nr. Idlewild, VII.10.27 (J. M. Aldrich). *Idaho:* ♂, 2 ♀, St. Charles, VIII.10.39; ♀, Paris, VIII.10.39 (G. F. Knowlton, F. C. Harmston). *Manitoba:* 2 ♂, The Pas, VIII.11.37 (R. H. Daggy); ♀, Churchill River, 20 mi. S. of Churchill, VIII.5–6.37 (D. G. Denning) [F. M. Snyder]. ♂, ♀, Strathclair, VII.15.26; ♂, Darlingford, VIII. 3.23; ♀, Lake Dauphine, VII.2.26 (N. Criddle) [C. N. C.]. *Michigan:* ♂, Detroit, IX.1.33 (Geo. Steyskal). *Missouri:* ♀, Atherton, V.15.16. *New York:* ♂, ♀, Canton, VII.27.31 (J. M. Aldrich) [U. S. N. M.]. *North Dakota:* ♂, ♀, Turtle Mts., near Bottineau, VI.21.18 [U. S. N. M.]. *Saskatchewan:* ♂, Dundern, VIII.19.– (N. Criddle); ♀, Birch Hills, VII.18.25 (K. M. King) [C. N. C.]. *South Dakota:* ♀, Fort Pierre, VIII.11.24; ♀, Custer, VII.17.24 [South Dakota State Col.]. *Utah:* ♂, Alton, IX.14.39; ♀, Lakota, VIII.5.39; ♂, Laketown, VIII.5.39 (G. F. Knowlton); ♀, Randolph, IX.21.38 (G. F. Knowlton, F. C. Harmston) [Utah Agr. Col.]. ♂, Geyser Pass, La Sal Mts., 10,000 ft. alt., no date, (Vasco M. Tanner) [Brigham Young Univ.]. *Washington:* 2 ♂, Medical Lake, VII.14.20 (R. C. Shannon). ♂, ♀, Pullman, no date, paratype of *elongata* Mall. [U. S. N. M.].

Hydrophoria borealis Malloch

Figures 13, 33, 39

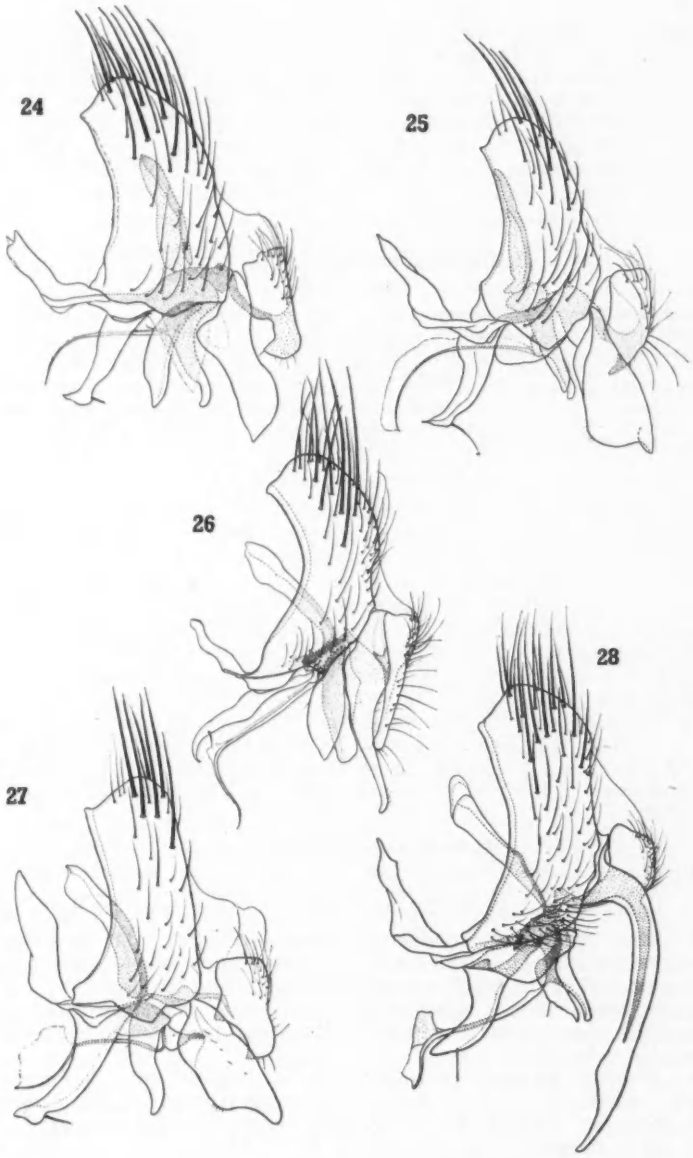
Hydrophoria borealis Malloch, Trans. Amer. Ent. Soc., 46: 172, 1920; Malloch, Can. Ent., 52: 255, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

The male of ***borealis*** has the abdomen tufted, and may be distinguished from closely related species possessing this character by the fact that the fourth abdominal tergum does not become conspicuously narrower toward the lateral margin (ventrad). This character is also true of the male of *wierzejskii*, which however differs in unique respects from other species belonging to the genus as already mentioned. In other ways ***borealis*** superficially resembles *flavohalterata*, the male of which has no true tuft in the accepted sense but does possess a number of closely placed bristles on the caudolateral area of the fourth abdominal tergum. In the female of ***borealis*** the tergal sclerites of the ovipositor are dull and opaque across the caudal region and the terminal plates possess ten to twelve coarse black spinules, whereas in *flavohalterata* the tergal sclerites are entirely polished and the terminal plates only possess four to six fine delicate spinules.

Material Examined.—Alaska: ♂, Anchorage, VI.11.21 (J. M. Aldrich) [U. S. N. M.]. 4 ♂, ♀, Katmai, June 1917; ♀, Savonoski, Naknek Lake, August 1919 (J. S. Hine). *Alberta:* ♂, Wabamun, VII.2.39 (E. H. Strickland) [Univ. Alberta]. ♂, Banff, VIII.18.22 (C. B. D. Garrett); ♀, Jasper, VII.25.23 (J. McDunnough) [C. N. C.]. *British Columbia:* ♂, ♀, Jordan River, VII.12.28 (W. Downes). ♂, Vancouver, V.20.–. *Idaho:* ♀, Priest Lake, (C. V. Piper) [U. S. N. M.].

EXPLANATION OF PLATE IV

Lateral aspect of male copulatory appendages. Fig. 24. *Hydrophoria lucidiventris* (Zetterstedt). 25. *H. fasciculata* (Schnabl). 26. *H. ambigua* (Fallén). 27. *H. ignobilis* (Zetterstedt). 28. *H. laticornis* (Ringdahl).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Minnesota: ♀, Aitkin County, VII.4.37 (F. M. Snyder). *New Hampshire:* 2 ♀, White Mts., (Morrison) [U. S. N. M.]. *Ontario:* ♂, Abitibi Region, VI.6–8.15 (Cook); ♀, Low Bush, Lake Abitibi, VI.10.25 (N. K. Bigelow) [C. N. C.]. *Washington:* ♀, Mt. Rainier, above Longmire's, 5,000 ft. alt., VIII.3.05 (J. M. Aldrich) [U. S. N. M.]. ♂, Granite Falls, VII.25.25; ♂, ♀, Snoqualmie Pass, VI.29.24; ♀, Big Four Mts., VII.5.24; ♀, Orcas Island, above Mt. Lake, VIII.18.25 (all A. L. Melander). 2 ♂, ♀, Mt. Constitution, VII.17.09, paratypes [U. S. N. M.]. *Wisconsin:* ♂, ♀, Apostle Island, Ashland County, VII.4–11.07 [F. M. Snyder].

Hydrophoria lucidiventris (Zetterstedt)

Figures 15, 24, 44

Aricia lucidiventris Zetterstedt, Dipt. Scand., 4: 1554, 1845.
Aricia barbiventris Zetterstedt, Dipt. Scand., 4: 1589, 1845.
Hydrophoria barbiventris Stein, Wien. Ent. Zeitg., 21: 30, 1902; Stein, Kat. Paläark. Dipt., 3: 684, 1907; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.
Acroptena barbiventris Stein, Arch. f. Naturgesch., (1913), 79 A (8): 32, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 134, 1916; Ringdahl, Ent. Tidskr., 39 (2): 186, 1918; Ringdahl, Trömso Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931.
Acroptena lucidiventris Ringdahl, Opusc. Entom., 4 (3–4): 149, 1939.

This species is listed by Séguy (1937) under the name *barbiventris* as occurring in North America. I have not been able to corroborate this record. A species that I consider tentatively as distinct from *lucidiventris* but which is evidently very similar was described by Malloch under the name *alaskensis*. My knowledge of *lucidiventris* is based on a large series of specimens collected in Swedish Lapland. In this material the male tuft arises closer to the basal region of the abdomen than in the case of *alaskensis*, in consequence of which the fifth tergum is proportionately longer along the lateral margin and the bristles composing the tuft, which reach to the end of abdomen, average longer than in *alaskensis*. Except for these rather arbitrary differences the males, in my opinion, agree in all other respects with males of *alaskensis*. I can find no specific differences between the respective females.

Hydrophoria alaskensis Malloch

Hydrophoria alaskensis Malloch, Can. Ent., 52: 257, 1920; Malloch, Proc. Cal. Acad. Sci., ser. 4, 11 (14): 182, 1921; Malloch, North Amer. Faun. No. 46, U. S. Dept. Agr., pp. 192, 227, 1923; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

I have tentatively considered *alaskensis* as apart from *lucidiventris* on the strength of male differences in the structure of the fifth abdominal tergum and in the relative position of the tuft on the abdomen. It is quite possible that a richer series of specimens showing a wider geographical distribution may indicate that these characters do not possess specific values.

Material Examined.—Alaska: ♂, St. George Id., Bering Sea, VI.8.14 (G. D. Hanna), holotype of *alaskensis*; 25 ♂, 28 ♀, same locality, VI.8–25.14 (G. D. Hanna), paratypes of *alaskensis* [U. S. N. M.]. ♀, St. Paul Island, VII.12.20 (G. D. Hanna). *Colorado:* ♂, Tennessee Pass, 10,240 ft. alt., VII.11.– (J. M. Aldrich). ♂, Summit Road, Ouray, 11,000 ft. alt., VII.13.19 [A. M. N. H.].

Hydrophoria implicata new name

Hydrophoria ambigua Stein not Fallén, Berl. Ent. Zeitschr., (1897), 42 (3–4): 208, 1898; Smith, Ann. Rept. N. J. State Museum 1909, p. 791, 1910; Malloch, Can. Ent., 52: 255, 257, 1920; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 15, 1924; Hallock and Parker, Circ. 103, N. J. Dept. Agr., p. 16, 1926; Leonard, Mem. 101, N. Y. (Cornell) Agr. Exp. Sta., (1926), p. 837, 1928.

Acroptena ambigua Johnson, Occ. Pap. Boston Soc. Nat. Hist., 7: 233, 1925.

Hydrophoria (Acroptena) ambigua Johnson, Insect Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927.

This widely distributed species has been recently recorded in North America as *ambigua* Fallén. This is undoubtedly a case of mistaken identity since it may be distinguished from Fallén's species by the tuft of bristles on the ventral surface of the male abdomen and by the sharply narrowing outline of the fourth tergum ventrad; in the female by the absence of bristles on the posteroventral surface of the hind femur. Females closely resemble *wierzejskii*, but differ in being slightly darker and having the veins on the basal region of the wings usually of a seal brown tinge, not yellowish. In addition there are no setulae at the base of the posterior notopleural bristle in either sex of *implicata*, whereas there are one or two inconspicuous setulae in this area in *wierzejskii*.

Material Examined.—British Columbia: ♂, St. Marys, VII.12.26 (A. A. Dennys); ♀, Oliver, VIII.18.23 (C. B. D. Garrett) [C. N. C.]. ♂, Kaslo, VII.17.– (H. G. Dyar) [U. S. N. M.]. *District of Columbia:* ♂, Washington, July, (Coquillett) [U. S. N. M.] *Idaho:* ♂, Priest Lake, VIII.1.16; ♀, Chatcolet, VIII.15.– (A. L. Melander) [U. S. N. M.]. *Illinois:* ♀, Cedar Lake, bog, VIII.6.06. *Maine:* ♀, Orrs Island, VII.28.07. ♀, Salisbury Cove, VII.15.23. 2 ♂, Pittston, VIII.3.30. ♂, Echo Lake, Mt. Desert, VI.17.21 (C. W. Johnson) [U. S. N. M.]. *Manitoba:* ♀, Churchill River, 20 mi. S. of Churchill, VIII.5–6.37 (R. H. Daggy) [F. M. Snyder]. *Massachusetts:* ♀, Chester, VIII.5.11. *Michigan:* 4 ♂, 2 ♀, Isle Royale, VIII.3–7.– (C. W. Sabrosky); ♂, Cheboygan County, VII.7.40 (R. I. Sailer) [Mich. State Col.]. ♂, Cusino, VI.26–27.40 (T. F. Boyce). *Minnesota:* ♂, Aitkin County, VII.4.37 (F. M. Snyder). *Montana:* ♀, Lake McDonald, Glacier Park, VIII.14.16 (A. L. Melander) [U. S. N. M.]. *New Brunswick:* ♂, Shippigan, VII.14.31 (J. M. Aldrich); ♂, St. John, VII.24.01 (W. McIntosh); ♀, Oromocto, VII.9.13 (J. D. Tothill) [U. S. N. M.]. *New Hampshire:* ♂, White Mts., Dolly Copp, VII.13.31. ♂, White Mts., (Morrison); ♂, base of Mt. Washington, 2,600 ft. alt., (C. H. T. Townsend) [U. S. N. M.]. *New York:* 2 ♂, Canton, VII.27.31 (J. M. Aldrich) [U. S. N. M.]. ♂, North Fairhaven, VII.4.22 (R. C. Shannon); 2 ♂, 2 ♀, Ontario Beach, North Fairhaven, VIII.8.21 (L. S. West); ♂, Lake George, VII.25.29; 2 ♀, McLean bogs, McLean, VIII.18.28; 2 ♂, 3 ♀, Ringwood, near Ithaca, VI.26.20; ♂, Michigan Swamp, near Ithaca, VII.23.20; ♀, Freeville, VII.26.21; ♂, Renwick, Ithaca, VIII.8.20; 2 ♂, 2 ♀, Harmon, VII.5.26; ♂, Statten Island, VII.23.21; ♀, Montezuma Marsh, Cayuga County, VI.1.20; ♂, Watchogue, VII.14.21; ♀, Little Neck, Long Island, VI.25.21. *Nova Scotia:* 2 ♂, Truro, VII.8.13 (R. Matheson). *Ontario:* ♂, Lyn, VIII.10.26 (G. S. Walley) [C. N. C.]. *Pennsylvania:* ♀, Germantown, VI.4.05 [U. S.

N. M.]. *Quebec:* ♂, ♀, Gaspé Bay, VII.17.31 (J. M. Aldrich) [U. S. N. M.]. ♂, Knowlton, VII.9.27 (G. S. Walley); ♀, Hemmingford, VI.26.23 (C. H. Curran) [C. N. C.]. *Saskatchewan:* ♀, Maryfield, VIII.31.16 (N. Criddle). *Washington:* ♂, Puget, VIII.30.31 (J. Wilcox). 2 ♂, Coulee City, IX.3.20 (R. C. Shannon). *Wisconsin:* 2 ♂, Cranmoor, VIII.30.09 (C. W. Hooker) [U. S. N. M.]. ♂, Dane County, VI.5.38 (F. M. Snyder). ♂, Madison, IX.29.18 (C. L. Fluke).

Hydrophoria fasciculata (Schnabl)

Figures 16, 25, 37

Acroptena fasciculata Schnabl, Mem. Acad. Imper. Sciences, Petrograd, ser. 8, 28 (7): 15, 1915.
Acroptena incisurata Ringdahl, Ent. Tidskr., 39 (2): 185, 1918; Ringdahl, Trömso Museums Arsheft., (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsårenden, Nr. 18, p. 18, 1931; Ringdahl, Ent. Tidskr., 53 (3): 174, 1931.
Hydrophoria fasciculata Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

The male of *fasciculata* resembles that of *implicata* in certain respects, but may be distinguished by the shorter hairs of the arista, shorter and less conspicuous tufts on the abdomen, a more pronounced fringe of setulae along the inner margin of the processes, and by being smaller. The female, unlike that of *implicata*, has weak bristles on the postero-ventral surface of the hind femur, and keys out close to *borealis* and *flavohalterata*, from both of which it may be distinguished by the slightly shorter-haired arista, the longest hairs being not much longer than the basal diameter of the arista. The female may further be distinguished from that of *borealis* in that the basal region of the wings is less distinctly tinged with fuscous, and from that of *flavohalterata* by the more shiny lustre of the dorsum of the thorax and abdomen.

Material Examined.—Alberta: ♀, Banff, V.5.22; ♂, ♀, same locality, VII.25.22 (C. B. D. Garrett) [C. N. C.].

Hydrophoria conica (Wiedemann)

Figures 2, 21, 35

Anthomyia conica Wiedemann, Zool. Mag., 1 (1): 79, 1817; Meigen, Syst. Beschr., 5: 97, 1826; Walker, List Dipt. Ins. Brit. Mus., 4: 917, 1849; Walker, Ins. Brit., 2: 134, 1853.
Musca dubitata Fallén, Muscides, p. 82, 1825.
Musca conica Fallén, Muscides, p. 83, 1825.
Anthomyia distincta Meigen, Syst. Beschr., 5: 101, 1826.
Anthomyia operosa Meigen, Syst. Beschr., 5: 102, 1826.
Hydrophoria sagittariae Rob.-Desv., Essai Myod., p. 505, 1830.
Hydrophoria tibialis Rob.-Desv., Essai Myod., p. 505, 1830.
Hydrophoria conica Macquart, Hist. Nat. Ins., 2: 298, 1835; Rondani, Dell. Soc. Ital. Sci. Natur., 9: 141, 1866; Rondani, Dipt. Ital., Prodr., 6: 172, 1877; Meade, Ent. Month. Mag., (1881–1882), 18: 102, 1881; Stein, Ent. Nachr., 14 (24): 375,

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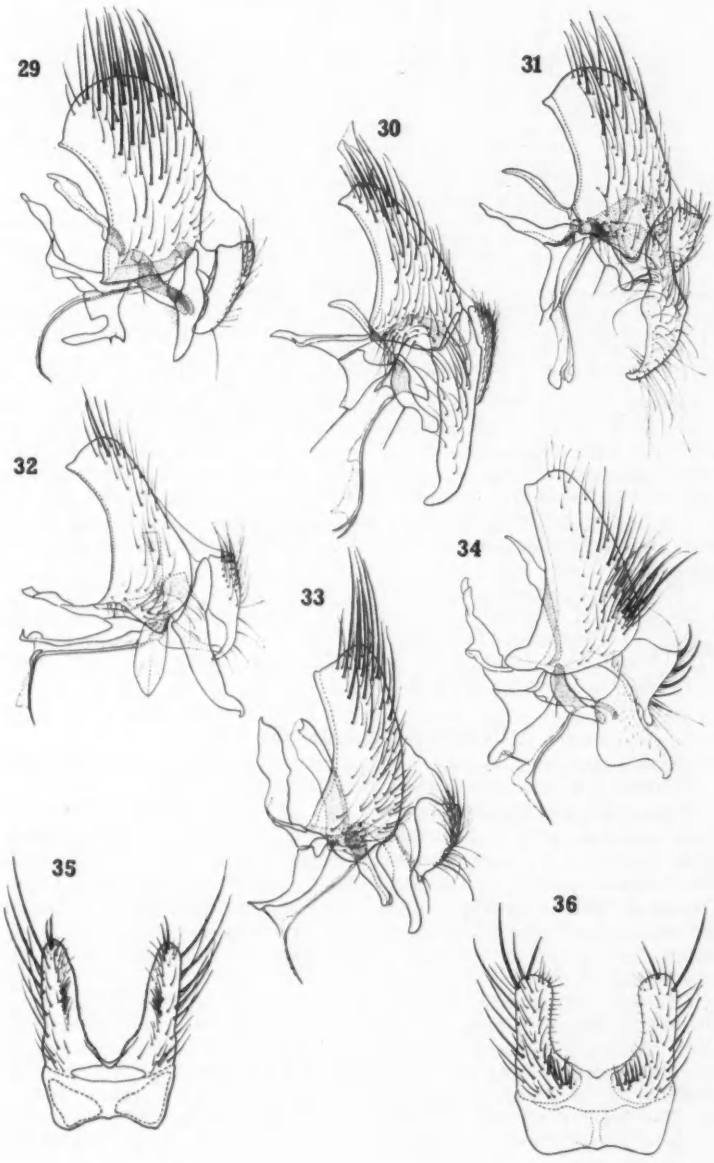
EXPLANATION OF PLATE V

Lateral aspect of male copulatory appendages. Fig. 29. *Hydrophoria zetterstadti* (Ringdahl). 30. *H. divisa* (Meigen). 31. *H. proxima* Malloch. 32. *H. wierzejskii* (Mik). 33. *H. borealis* Malloch. 34. *H. seticauda* Malloch. Ventral aspect of fifth abdominal sternum in male. 35. *H. conica* (Wiedemann). 36. *H. ruralis* (Meigen).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1888; Strobl, Verh. zool.-bot. Ges. Wien, 43: 244, 1893; Meade, Descr. List Brit. Anth., 1: 31, 1897; Stein, Kat. Paläark. Dipt., 3: 684, 1907; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 137, 1916; Séguy, Faune de France, 6: 141, 1923; Ringdahl, Trômso Museums Arshefter, (1926), 49 (3): 34, 1928; Karl, Tierwelt Deutschlands, 13 (3): 119, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps, Skrift. Naturskyddsärenden, Nr. 18, p. 17, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31, 1935; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

Hydrophoria caesia Macquart, Hist. Nat. Ins., 2: 298, 1835.

Hylemyia nigricans Meigen, Syst. Beschr., 7: 321, 1838.

Anthomyza conica Zetterstedt, Ins. Lapp., p. 689, 1938; Zetterstedt, Dipt. Scand., 4: 1652, 1845; Siebke, Enum. Insect. Norveg., p. 117, 1877.

Anthomyza monticola Zetterstedt, Dipt. Scand., 8: 3306, 1849; Siebke, Enum. Insect. Norveg., p. 118, 1877.

Anthomyza inquirenda Zetterstedt, Dipt. Scand., 8: 3307, 1849.

Anthomyia subtracta Walker, Ins. Brit., 2: 135, 1853.

Hylemyia conica Schiner, Faun. Austr., 1: 631, 1862; Neuhaus, Dipt. March., p. 224, 1886; Pandellé, Rev. Ent. France, 18: 216, 1899.

Hydrophoria conica alpicola Strobl, Mitt. Verh. Steiermark., (1897), p. 244, 1898.

This well known European species has hitherto remained unrecorded from North America. It is typical of a small group of species which lack the three characteristic black vittae along the thorax; all the species are without a medial anteroventral bristle on the mid tibia, the hairs of the arista are pectinate, and in the female the caudal pair of ocellar bristles is widely divergent and directed outwards. *Conica* has a long prealar bristle, and is larger than the related forms *ruralis* and *galeata*.

Material Examined.—Connecticut: 4 ♂, 2 ♀, Litchfield County, V.30.39 (F. M. Snyder). ♂, Redding, V.30.31 (A. L. Melander). *New York:* ♀, Riverhead, Long Island, VI.26.27; ♀, Orient, Long Island, VI.6.36; ♀, same locality, VI.20.36 (H. C. Huckett). 3 ♂, Patterson, V.19.35 (H. Dietrich) [C. U.].

Hydrophoria galeata Malloch

Hydrophoria galeata Malloch, Ohio Jour. Sci., 20 (7): 270, 1920; Malloch, Can. Ent., 52: 254, 1920; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species is closely related to *ruralis*, and both belong to the same segregate with *conica*. The male of *galeata* may be distinguished from that of *ruralis* by the wider parafacials, the presence of a bristle on the posterior surface of the hind tibia, and by the entirely blackish abdomen. In the female of *galeata* the marginal bristles of tergum 5 are weaker, and the abdominal vitta on the basal two segments is less widely developed than in *ruralis*. The tibiae may be blackish, brownish or yellowish in color.

Material Examined.—Alaska: ♂, Savonoski, Naknek Lake, June 1919 (J. S. Hine). *Alberta:* ♂, Gull Lake, VI.19.29 (E. H. Strickland) [Univ. Alberta]. ♂, Banff, VI.29.17; ♀, Chin, VI.7.23 (H. L. Seamans). *British Columbia:* ♀, Oliver, V.9.23 (C. B. D. Garrett) [C. N. C.]. *Colorado:* 5 ♀, no data, (Coquillett) [U. S. N. M.]. ♀, Cuchara, 10,000 ft. alt., VIII.7.40 (F. M. Snyder). *South Dakota:* ♂, Mobridge, VIII.13.24. ♀, Custer, VII.15.24. *Utah:* ♂, Ogden, VI.26.37 (D. E. Hardy).

Hydrophoria ruralis (Meigen)

Figures 8, 20, 36

Anthomyia ruralis Meigen, Syst. Beschr., 5: 101, 1826; Walker, List Dipt. Ins. Brit. Mus., 4: 919, 1849.
Hydrophoria testacea Rob.-Desv., Essai Myod., 506, 1830; Macquart, Hist. Nat. Ins., 2: 298, 1835.
Hydrophoria maculata Macquart, Hist. Nat. Ins., 2: 299, 1835.
Hydrophoria maculata Meigen, Syst. Beschr., 7: 320, 1838.
Hydrophoria anthomyiea Rond., Dell. Soc. Ital. Sci. Natur., 9: 141, 1866; Rondani, Dipt. Ital., Prodr., 6: 171, 1877; Stein, Ent. Nachr., 14 (24): 375, 1888; Meade, Entom. Month. Mag., 18: 103, 1881; Strobl, Verh. zool.-bot. Ges. Wien, 43: 243, 1893; Meade, Descr. List Brit. Anth., 1: 31, 1897.
Hylemyia ruralis Neuhaus, Dipt. March., p. 224, 1886.
Hylemyia plumosior Pandellé, Rev. Ent. France, 18: 216, 1899.
Hydrophoria ruralis Stein, Kat. Paläark. Dipt., 3: 687, 1907; Stein, Arch f. Naturgesch., 77 A (1): 149, 1911; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch f. Naturgesch., (1915), 81 A (10): 137, 1916; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Séguy, Faune de France, 6: 142, 1923; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 16, 1924; Karl, Tierwelt Deutschlands, 13 (3): 119, 1928; Leonard, Mem. 101, N. Y. (Cornell) Agr. Exp. Sta., (1926), p. 837, 1928; Séguy, Gen. Insect. Fasc. 205, p. 134, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.
Hydrophoria subpellucida Malloch, Trans. Amer. Ent. Soc., 44: 296, 1918; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.
Hydrophoria subpellucens Malloch, Can. Ent., 52: 254, 256, 1920; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

In typical forms *ruralis* has the abdomen tinged with yellowish on the basal half, and in the male the fourth and fifth terga possess a pair of brownish marks on the cephalic region in addition to a dorsocentral vitta. The distal half of the proboscis is slightly stouter than in *galeata*, and in the female the marginal bristles of tergum 5 are more strongly developed and the dorsocentral vitta on the two basal abdominal segments considerably wider than in *galeata*. The female specimens from Banff do not exhibit the yellowish color on abdomen, but otherwise they conform closely to the characters possessed by *ruralis*. Malloch (1920) recognized the similarity between *subpellucida* and *ruralis*, but preferred to treat them as distinct species pending further study. The males of North American specimens differ from those of Europe that I have seen in having the preapical posterodorsal bristle and one or two adjacent setulae on the hind tibia fine and longish, and in both sexes the number of anterodorsal bristles is usually greater. Otherwise, in my opinion, there seems to be no significant differences between the two forms to warrant their recognition as distinct species.

Material Examined.—Alberta: 3 ♀, Banff, IX.12.36 (T. D. A. Cockerell) [Univ. Alberta]. *Arizona:* 9 ♂, 2 ♀, Cave Creek Canyon, Chiricahua Mts., VII.4–8.40 (D. G. Hall). *New Mexico:* ♂, Alamogordo, IV.30.02, type of *subpellucida* Mall. [A. N. S. P.].[13] *New York:* ♂, Ithaca, no date, (O. A. Johannsen) [C. U.]. *North Carolina:* ♀, no date [U. S. N. M.]. *Pennsylvania:* ♂, Westmor County, July [Carnegie Museum]. *Ohio:* ♂, Vinton, VI.5–12.00 (J. S. Hine). *South Dakota:* ♀, Pierre, no date (J. M. Aldrich) [U. S. N. M.]. *West Virginia:* ♂, Cheat River, June [Carnegie Museum].

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Hydrophoria zetterstedti (Ringdahl)

Figures 14, 29, 38

Acroptena zetterstedti Ringdahl, Ent. Tidskr., 39 (2): 185, 1918; Ringdahl, Trömso Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935; Séguy, Gen. Insect., Fasc. 205, p. 135, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

This species may be readily distinguished from related forms by the possession of the following combination of characters: a long prealar bristle, minutely-haired arista, two medial anterodorsal bristles on mid tibia, yellowish tinge to basal region of wings and to calyptrae. The hypopleura is not haired on the upper margin nor is the abdomen tufted. I have seen specimens of *laticornis* that approach *zetterstedti* on the basis of such characters, but in the male of *laticornis* the processes have a few longish bristles on the outer surface, and in the female the anal palpi are dull and opaque, whereas in *zetterstedti* the processes are finely and weakly setose and the anal palpi are lustrous and shiny.

Material Examined.—Alaska: ♀, Healy, V.26.21. ♂, ♀, Yakutat, VI.21.99 (T. Kincaid) [U. S. N. M.]. *Alberta:* ♂, Gull Lake, VI.4.39; ♂, Wabamun, VII.2.39; ♀, Edmonton, VI.7.35 (E. H. Strickland); ♂, Cooking Lake, VI.13.37 (F. O. Morrison) [Univ. Alberta]. ♀, Waterton, VII.2.24 (H. L. Seamans); 2 ♂, Banff, V.31.22 (C. B. D. Garrett) [C. N. C.]. *Montana:* ♀, Glacier Park Station, 4,800 ft. alt., VII.24.– (J. M. Aldrich) [U. S. N. M.]. *Ontario:* ♀, Low Bush, Lake Abitibi, VI.24.25 (N. K. Bigelow) [C. N. C.].

Hydrophoria seticauda Malloch

Figures 6, 34, 47

Hydrophoria seticauda Malloch, Proc. Cal. Acad. Sci., ser. 4, 9 (11): 306, 1919; Malloch, Can. Ent., 52: 254, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

The male of *seticauda* may be readily recognized owing to the flattish appressed character of the ninth tergum when viewed from behind, which serves to give the abdomen an abrupt truncated appearance. The anal sclerite is clothed with weak bristles which become denser caudad (ventrad), and which curl inward at tip. The medial bristles of the marginal series on tergum 5 are much further from the caudal margin than those situated laterad, the integument along the caudal border being extensively membranous. The hind tibiae usually possess one or two short bristles on the proximal half of the posterior or posteroventral surface. The female, like the male, has one or more pairs of weak pre-

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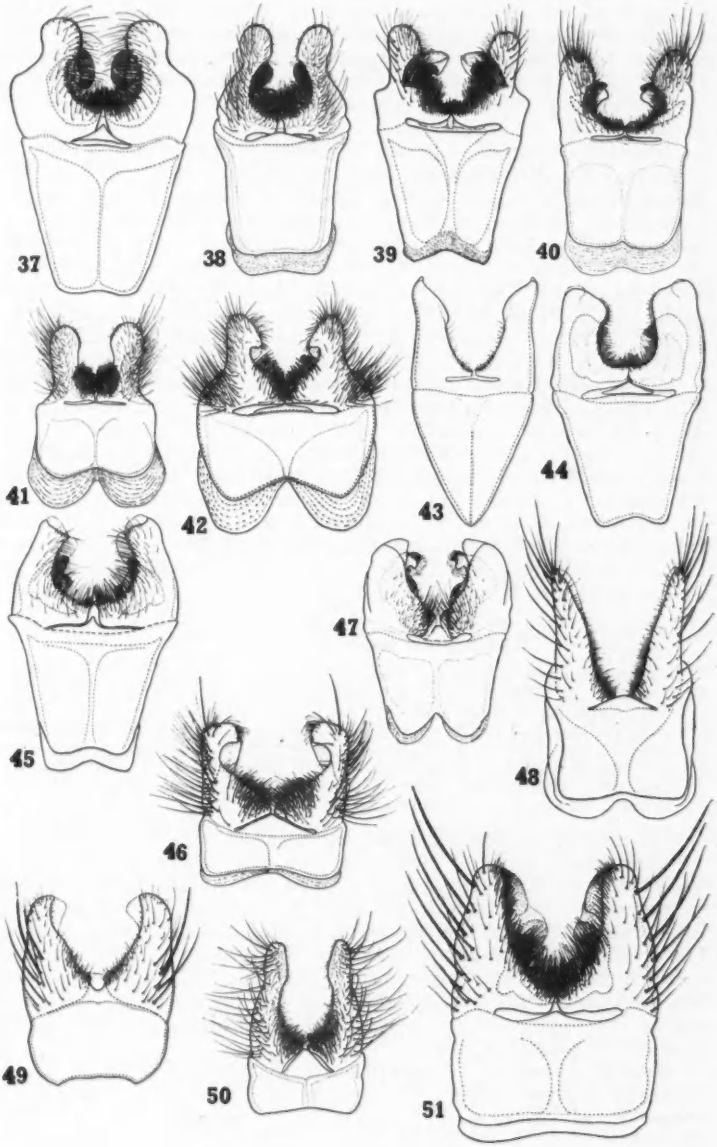
EXPLANATION OF PLATE VI

Ventral aspect of fifth abdominal sternum in male. Fig. 37. *Hydrophoria fasciculata* (Schnabl). 38. *H. zetterstedti* (Ringdahl). 39. *H. borealis* Malloch. 40. *H. ambigua* (Fallén). 41. *H. frontata* (Zetterstedt). 42. *H. verticina* (Zetterstedt). 43. *H. wierzejskii* (Mik). 44. *H. lucidiventris* (Zetterstedt). 45. *H. ignobilis* (Zetterstedt). 46. *H. katmaiensis* Malloch. 47. *H. seticauda* Malloch. 48. *H. divisa* (Meigen). 49. *H. proxima* Malloch. 50. *H. brunneifrons* (Zetterstedt). 51. *H. laticornis* (Ringdahl).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sutural acrostical bristles, the aristal hairs are about as long as half the width of the third antennal segment, the terminal sclerites of the ovipositor are armed with about twelve coarse blackish spinules. From females of ***ambigua*** (Fallén) the species may be distinguished by the absence of setulae at the base of the posterior notopleural bristle and by the blackish and more shiny abdomen, resembling the femora in this respect.

Material Examined.—Alaska: ♂, Port Althorp, VI.5.21 (J. M. Aldrich); ♂, Mablakahbla, VI.4.99 (T. Kincaid) [U. S. N. M.]. *British Columbia:* ♂, Vancouver, VI.9.06 (R. S. Sherman). ♂, Agassiz, V.27.27 (H. H. Ross) [C. N. C.]. *California:* ♂, Mill Creek Canyon, San Bernardino Mts., VI.9.24 (J. M. Aldrich) [U. S. N. M.]. *Idaho:* ♂, ♀, Mt. Moscow, VI.4.10. 2 ♀, Mts., Moscow, VI.25.20 (R. C. Shannon). ♂, St. Regis Pass, VII.1.23 (A. L. Melander). ♀, Moores Lake, VII.10.07 (J. M. Aldrich) [U. S. N. M.]. *Nevada:* ♂, Ormsby County, VII.6.– (Baker) [U. S. N. M.]. *Oregon:* ♂, Eddyville, III.30.30 (J. Wilcox). 3 ♂, Marshfield, VI.28.– (J. M. Aldrich) [U. S. N. M.]. ♂, Hood River, no date (Childs). ♀, Corvallis, V.8.29 (John Wieting). ♀, Melhorn's Mill, near Halfway, Baker County, VII.4.22 (W. J. Chamberlain). *Utah:* ♂, Salt Lake, VI.24.22, 6–7,000 ft. alt. (A. L. Lovett). ♀, Strawberry Valley, VI.27.40 (G. F. Knowlton, F. C. Harmston). ♂, Logan Canyon, VII.25.37 (G. F. Knowlton). *Washington:* ♀, Ilwaco, VII.12.18 (A. Spuler). ♀, Fairfax, VII.12.30. ♂, Valleyford, V.17.24; ♂, Hudson Creek, VI.29.24; 2 ♀, Granite Falls, VII.25.25; 2 ♀, Snoqualmie Pass, VI.29.24 (A. L. Melander). 2 ♀, Friday Harbor, VII.6.05; ♀, Longmire's Springs, Mt. Rainier, VIII.2.05 (J. M. Aldrich) [U. S. N. M.].

Hydrophoria uniformis Malloch

Hydrophoria uniformis Malloch, Trans. Amer. Ent. Soc., 44: 297, 1918; Malloch, Can. Ent., 52: 255, 256, 1920; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 16, 1924; Johnson, Occ. Pap. Boston Soc. Nat. Hist., 7: 233, 1925; Hallock and Parker, Circ. 103, N. J. Dept. Agr., p. 16, 1926; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 201, 1927; Johnson, Insect Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927; Leonard, Mem. 101, N. Y. (Cornell) Agr. Exp. Sta., (1926), p. 837, 1928; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937; Brimley, Insect. North Carolina, p. 376, 1938.

The male of ***uniformis*** may be distinguished from related forms by the conspicuous series of curling bristles and slender setulae arising respectively along the entire length of the outer and inner surfaces of the processes. In both sexes the mid tibia lacks the normal preapical mid-dorsal bristle, and the parafacials become much narrower ventrad. The dorsum of the abdomen is marked transversely by dark marginal incisures, being most conspicuous in the male. The species may or may not possess weak bristle-like setae among the presutural acrosticals and on the upper anterior region of the mesopleura adjacent to the anterior notopleural bristle.

Material Examined.—Connecticut: ♀, Branford, VII.28.05 (H. L. Viereck). *Georgia:* 10 ♂, Clayton, IV.15–22.40 (H. C. Huckett). *Idaho:* ♂, Mt. Moscow, VII.12.24; ♂, ♀, Moscow, VII.17.24; ♀, Elk River, VII.15.10 (J. M. Aldrich) [U. S. N. M.]. *Illinois:* ♂,

Urbana, IV.6.09; ♂, same locality, IV.5.09, paratypes [U. S. N. M.]. *Maryland:* 2 ♂, Beltsville, IV.30.16; 5 ♂, same locality, VII.4–30.16 (W. L. McAtee), paratypes [U. S. N. M.]. ♂, Lakeland, VII.5.09 (Fredk. Knab) [U. S. N. M.]. *Massachusetts:* ♂, Petersham, VI.30.31 (A. L. Melander). *New Jersey:* ♀, Ridgewood, VII.5.11 (M. D. Leonard). *New York:* ♀, Oswego, VII.17.96 [U, S, N, M,]. ♂, McLean Bogs, Tompkins County, VI.30.21; 8 ♂, Ringwood, near Ithaca, VI.26.20; ♂, Slaterville, VIII.16.28; 8 ♂, Buttermilk, near Ithaca, VII.10.20; ♂, Michigan Swamp, Tompkins County, VII.23.20; ♀, Statten Island, VII.23.21; ♀, Roslyn, Long Island, VIII.25.21 (H. C. Huckett). ♂, Ithaca, VI.22.36 [C. U.]. *Ohio:* ♂, Cranberry Harvest, Buckeye Lake, Licking County, VI.13.31 (M. D. Neiswander) [Ohio State Museum]. ♂, Sugar Grove, VI.10.28 [U. S. N. M.]. *Ontario:* ♀, Low Bush, Lake Abitibi, VI.10.25 (N. K. Bigelow). *Pennsylvania:* ♂, ♀, Allegheny County, June [Carnegie Museum]. *Quebec:* ♀, Rigaud, VII.20.20. *Vermont:* ♀, St. Albans, VI.19.13 (C. W. Johnson). *Virginia:* 2 ♂, Dead Run, Fairfax County, V.27.25 (R. C. Shannon); ♂, Falls Church, VI.21.14; 2 ♂, Four Mile Run, VII.13.12 (Fredk. Knab); ♂, Black Pond, VIII.27.19; 4 ♂, Great Falls, VI.25.20 (C. T. Greene); ♂, Roslyn, III.24.– (Townsend); 2 ♂, Occoquan, V.27.23 (J. M. Aldrich) [U. S. N. M.]. *West Virginia:* 3 ♂, Cheat Mts., June [Carnegie Museum]. *Wisconsin:* 4 ♂, Dane County, V.22.36 (F. M. Snyder).

Hydrophoria ignobilis (Zetterstedt)

Figures 12, 27, 45

Aricia ignobilis Zetterstedt, Dipt. Scand., 4: 1448, 1845.
Hydrophoria ignobilis Stein, Wien. Ent. Zeitg., 21: 33, 1902; Stein, Kat. Palāark. Dipt., 3: 686, 1907.
Acroptena ignobilis Stein, Arch. f. Naturgesch., (1913), 79 A (8): 32, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 134, 1916; Ringdahl, Ent. Tidskr., 39 (2): 188, 1918; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Ringdahl, Trömso Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937; Ringdahl, Opusc. entom., 4 (3–4): 149, 1939.

This small species superficially resembles *flavohalterata* and *borealis*. In the male of *borealis* however the abdomen is tufted on tergum 4, whereas in *flavohalterata* and *ignobilis* the caudoventral region of tergum 4 bears a loose series of longish appressed bristles, which is not to be confused with the characteristic "tuft" on many species in the genus. In both sexes of *ignobilis* the hind femur is usually bare on the posteroventral surface, or occasionally may possess a single bristle at the middle, whereas in *flavohalterata* the bristles occur in series on the proximal third of the posteroventral surface. Further, in the male of *ignobilis* the bristles on the posteroventral surface of the mid femur are uniformly short, scarcely as long as the width of the femur where situated. The female of *ignobilis* may be separated from its closest relatives by the bare posteroventral surface on the hind femur. The species runs out with *seticauda* in the female key, being distinguished from the latter by the absence of weak bristle-like setae among the

presutural acrosticals, and by the coarser spinular development of setulae across the cephalic border of the mesonotum.

Material Examined.—Alaska: 2 ♂, Fairbanks, VII.3.21; ♀, Camp 334, Alaska Eng. Comm., VII.9.21 (J. M. Aldrich). *Alberta:* ♂, 2 ♀, Banff, VIII.18.22; ♂, same locality, V.25.22 (C. B. D. Garrett) [C. N. C.].

Hydrophoria ambigua (Fallén)

Figures 10, 26, 40

Musca ambigua Fallén, Muscides, p. 56, 1823.

Anthomyia ambigua Meigen, Syst. Beschr., 5: 192, 1826; Walker, List Dipt. Ins. Brit. Mus., 4: 925, 1849.

Aricia ambigua Zetterstedt p. p., Dipt. Scand., 4: 1415, 1845; Zetterstedt, Dipt. Scand., 12: 4719, 1855; Zetterstedt, Dipt. Scand., 14: 6204, 1860; Siebke, Enum. Insect. Norveg., 4: 104, 1877.

Spilogaster ambigua Schiner, Faun. Austr., 1: 612, 1862.

Hydrophoria ambigua Rondani, Dell. Soc. Ital, Sci. Natur., 9: 140, 1866; Rondani, Dipt. Ital., Prodr., 6: 175, 1877; Meade, Ent. Month. Mag., (1881–1882), 18: 102, 1881; Stein, Ent. Nachr., 14 (24): 375, 1888; Strobl, Verh. zool.-bot. Ges. Wien, 43: 242, 1893; Meade, Descr. List Brit. Anth., 1: 30, 1897; Pandellé, Rev. Ent. France, 19: 221, 1900; Coquillett, Proc. Wash. Acad. Sci., 2: 447, 1900; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905; Stein, Kat. Paläark. Dipt. 3: 684, 1907; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

Acroptena ambigua Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch, Akad. Naturforsch., 95 (2): 103, 1911; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 133, 1916; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Séguy, Faune de France, 6: 146, 1923; Karl, Tierwelt Deutschlands, 13 (3): 120, 1928; Ringdahl, Trömso Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Collin, Ent. Month. Mag., 66: 228, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935.

Hydrophoria coloradensis Malloch, Trans. Amer. Ent. Soc., 46: 172, 1920; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

The male of ***ambigua*** has no true tuft as in ***implicata***, with which species it has been confused, but does possess a number of fine longish bristles along the lateral borders of abdominal terga 4 and 5. The processes have an outer series of weak bristles and an inner series of fine setulae from base to apex; the basal plate of the fifth sternum is invariably conspicuous, being black and polished. The abdomen is cinereous gray with the dorsocentral vitta becoming perceptably narrower caudad with each successive segment. The female of ***ambigua*** is more densely cinereous, the terga of the ovipositor are dull and opaque, not polished and lustrous as in ***flavohalterata***, and in some specimens there is a pair of weak bristle-like setae among the presutural acrosticals.

Material Examined.—Alaska: ♀, Fairbanks, VII.2.21 (J. M. Aldrich) [U. S. N. M.]. *Colorado:* ♂, Pingree Park, no date, (Vasco M. Tanner). ♂, Platte Canyon, near Idlewild, VII.10.27; ♂, Tennessee Pass, VII.17.17 (J. M. Aldrich), holotype of *coloradensis* Mall. [U. S. N. M.]. ♀, Long Lake, Boulder County, August, (T. D. A. Cockerell). ♀, Cameron Pass, VIII.19–22.40 (Sabrosky). ♂, Gould, VIII.18.40 (G. F. Knowlton). *Utah:* ♂, Geyser Pass, La Sal Mts., 9,500 ft. alt., no date (Vasco M. Tanner). *Washington:* ♀, Pullman, V.22.23 (A. L. Melander). ♀, Ilwaco, VI.6.18 (A. Spuler).

Hydrophoria flavohalterata Malloch

Hydrophoria flavohalterata Malloch, Trans. Amer. Ent. Soc., 46: 171, 1920; Malloch, Can. Ent., 52: 255, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

The male of *flavohalterata* structurally resembles that of *ambigua* (Fallén), differing in that the dorsocentral vitta of the abdomen is nearly uniformly broad on terga 3, 4 and 5, and the dark anterior incisures are more in evidence. In both sexes the presutural acrosticals are all setulose, and in the female the tergal sclerites of the ovipositor are entirely polished and shining, whereas in *ambigua*, *borealis*, *fasciculata* and *ignobilis* the terga are at least partly dull and opaque. This species was erroneously included in the New York list from specimens which have since been found to be representative of *implicata*. The species *flavohalterata* comes closest to the European form *tristis* Ringdahl,[14] with which it may eventually be found to be identical.

Material Examined.—Idaho: ♂, Moscow, VI.5.12; ♀, same locality, VI.6.12 (J. M. Aldrich), holotype and allotype [U. S. N. M.]. ♂, Newman, Lake, V.16.25 (A. L. Melander). 2 ♂, Lawyers Canyon, VI.16.09, paratypes [U. S. N. M.]. *Utah:* ♀, Card Canyon, Logan Canyon, VII.24.38 (W. P. Nye). *Washington:* ♂, Kampiac Butte, VI.1.12, paratype; ♂, Loon Lake, V.16.24 (A. L. Melander). ♀, Pullman, V.12.12; ♀, Uniontown, VI.26.32 (J. M. Aldrich) [U. S. N. M.]. 2 ♀, Ewan, VI.13.20 (R. C. Shannon).

Hydrophoria packardi Malloch

Hydrophoria packardi Malloch, Ann. Mag. Nat. Hist., ser. 9, 14: 514, 1924; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

This species belongs to the *frontata* segregate, closely resembling *frontata* itself. I have seen only a male specimen of the species, taken at Nairn, Labrador, which belonged to the collection of the Biological Survey of the United States Department of Agriculture. Unfortunately this specimen has become mislaid, and since my notes are too incomplete it is not possible at this time to discuss its relationships and taxonomy. The type was collected on Caribou Island, Labrador, according to its description.

[14]Ringdahl, O. Neue nordische Musciden nebst Berichtigung und Namensanderungen. Ent. Tidskr., 47 (2): 107, 1926.

A NEW SUBFAMILY OF BEETLES PARASITIC ON MAMMALS, STAPHYLINIDAE, AMBLYOPININAE, by CHARLES H. SEEVERS. Zool. Series, Field Museum of Natural History, Vol. 28, No. 3, pp. 155–172, pls. 10–12, 1944.

It has been known to Coleopterists since 1875 that Amblyopinus (South America) was frequently collected from rodents and marsupials, in some cases with its mandibles imbedded in the mammal's skin. Enough evidence has now been gathered to warrant the conclusion that it is a blood-sucking parasite. Seevers raises this genus to subfamily rank, reviews the genus, gives a key to the species and three plates on anatomy.—C. H. K.

NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA
PART XI.[1] (Tipulidae, Diptera)

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The species described herewith are all from the vicinity of Mount Abitagua, Ecuador. The conditions obtaining around Abitagua have been briefly discussed in the preceding part under this title while still further notes concerning it are given by F. Martin Brown in his notable contribution to our knowledge of Ecuadorean Entomological Localities (Ann. Ent. Soc. America, 34: 809–851, 10 maps; 1941). The region has proved to be so prolific in species of insects that I have asked Mr. William Clarke-Macintyre, the collector of this and other rich series of Tipulidae, to describe it in somewhat more detail. I feel certain that the following supplementary notes concerning Mount Abitagua will be of much value to many students at this time and in the future.

"Mount Abitagua is really a low range of hills, beginning just east of the Rio Topo and extending along the Pastaza to the Rio Quilo, between here and Mera. The highest point of the range is called by the natives 'The Hill of Abitagua,' lying directly north of my place. This Abitagua Range at its highest point probably rises to 2,000 meters; there is then a rather broad plateau followed by a descent toward the north to a valley where rise the Rios Quilo, Mango Yacu and Anzu. North of this valley is the Llanganati Range of much higher hills, some of them snow-capped. I think that Abitagua is the remains of an old volcano although there is no lava or pumice in this immediate region; however, on the very highest point of the range there exists a small lake which from all descriptions must be an old crater lake. The slope of the 'Hill of Abitagua' comes down to the Pastaza between the Rios Abitagua and Ergano. The trail from Mera to Baños runs along a shoulder on that slope and takes quite a dip between the two rivers mentioned. Old earthquakes and landslides have shaped the hills into steps or shoulders.

"The Pastaza, which is 1800 meters above sea-level at Baños about 30 miles to our west has descended 800 meters during this distance. From here to Mera it descends about 100 meters more. At some places the last step or cliff descends abruptly to the river, almost forming a cañon, at other places leaving a sort of beach or 'playa' which varies in width from 10 to 100 meters. Excepting the Pastaza, the so-called rivers (Mera to Baños, east to west: Rio Ergano, Guillermino, Fox, Industria, Bella Vista and Abitagua) are really no more than small creeks, the larger ones about 10 meters wide where crossed by the trail.

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[1]Contribution from the Entomological Laboratory, Massachusetts State College.

The preceding part under this general title was published in the Annals of the Entomological Society of America, 36: 103–127, 1943.

From the trail to the Pastaza they have cut deep gorges, a fine collecting spot for certain rare Tipulidae and Odonata. In the Pastaza, immediately in front of my place, are two small islands, from one to two hectares in area. When the river is low, the channel between my shore and one of these islands is completely dry, with only a few stagnant pools of water. There is always water between the shore and the second island but for about one-half the time it is only ankle-deep and fordable. Just west of the Rio Industria the cliff has worn down to a gentle slope to the river, the only one along the entire road between Baños and Mera; everywhere else one has to climb down the bank to the lowest playa. There is no sedimentary rock in the soil of Abitagua. Geologists of the Royal Dutch Shell Company state that the core of the range is granite. Immediately in front of my house is a gravel pit and the soil is evidently alluvial as many of the stones are water-worn. Top-soil in no place is very deep, in some places non-existent. The only spot that is boggy is about one-half of Mayorga's Playa and about one-half of a pasture between the Rios Fox and Guillermino.

"The temperature here runs: 6 A. M.—16° C.; Noon—20–22° C.; 7 P. M.—17° C., with very little variation. The dry season, so-called, is from December to April but the only difference is that it rains more in the so-called wet season. Absolutely clear sunny days during the dry season average about eight per month, in the wet season about four or five. However even during the wet season it seldom rains all day, there generally being an hour or two of sun either in the morning or afternoon. It appears that each of the small streams or rios flowing into the Pastaza, as listed above, supports its own peculiar fauna, at least in certain groups of insects."—*William Clarke-Macintyre.*

Ozodicera Westwood

Ozodicera (Ozodicera) piatrix sp. n.

General coloration dark brown, the scutellum, postnotum and pleura more pruinose; flagellar branches (male) subequal in length to the stems, simple; femora with a narrow, nearly apical, brownish black ring; wings with a strong grayish brown tinge, the prearcular and costal fields darker brown; stigma and a cloud on anterior cord conspicuously darker brown; male hypopygium with the basistyle produced at apex into an acute glabrous blackened spine; outer dististyle clavate, heavily blackened, the outer face of the apical club provided with abundant short erect setae.

Male.—Length, about 25 mm.; wing, 22 mm.; antenna, about 7 mm.

Frontal prolongation of head elongate, brownish black; nasus distinct; palpi black. Antennae (male) relatively long, brownish black, the pedicel and the incisures of the basal two or three flagellar segments very restrictedly paler; flagellar branches entirely simple and relatively short, subequal in length to but stouter than the segments themselves; simple terminal flagellar segments about equal in length to the remainder of antenna combined. Head dark grayish brown; anterior vertex narrow, about two-thirds the diameter of scape.

Pronotum brownish black. Mesonotum almost uniform dark brown, without distinct markings with the exception of a capillary more blackened vitta on cephalic portion of praescutum; scutellum and postnotum more heavily light gray pruinose. Pleura dark gray, the dorsopleural region still darker, more brownish black. Halteres black, the base of stem narrowly obscure yellow. Legs with the coxae gray pruinose; trochanters yellowish brown; femora obscure brownish yellow, each with a narrow, nearly apical, brownish black ring; tibiae brownish yellow, passing into black; tarsi black. Wings relatively narrow, with a strong grayish brown tinge, the prearcular region and cells *C* and *Sc* still darker brown; the narrowly oval stigma and a cloud on anterior cord conspicuously darker brown; veins light brown, somewhat darker in the costal portions. Venation: Cell M_1 rather broadly sessile.

Abdomen relatively long, black, sparsely pruinose, the basal tergal rings more reddish brown; hypopygium a little brightened. Ninth tergite of the male hypopygium with a small V-shaped median notch, the lateral lobes broadly truncated and provided with long setae. Basistyle produced at apex into a blackened glabrous spine, the tip acute. Outer dististyle heavily blackened, the basal half constricted, the apex expanded into an oval club provided with abundant short erect setae on outer face. Inner dististyle slender, curved, the apex terminating in two acute, slightly unequal spines; outer face of style near base produced into a stout triangular point and here provided with numerous very long and conspicuous yellow setae. Gonapophyses appearing as simple yellow rods subtending the shorter aedeagus, their tips acute.

Holotype, ♂, Abitagua, altitude 1,100 meters, May 26, 1941 (Macintyre); in spider's web.

Ozodicera (*Ozodicera*) *piatrix* is entirely different from the now relatively numerous species of the subgenus, differing especially in the structure of the male hypopygium, as the glabrous blackened spine of the basistyle and the darkened clavate outer dististyles. None of the regional species in Amazonian Peru, Ecuador or Brazil is closely allied.

Tanypremna Osten Sacken

Tanypremna (**Tanypremnella**) **mediocornis** sp. n.

General coloration orange yellow, the thorax unpatterned; antennae (male) of moderate length, approximately one-half the length of body, the vestiture of the flagellar segments abundant and dense but short; legs dark brown, unpatterned; wings weakly tinted, stigma pale brown; *r-m* connecting with *Rs* at or just before the fork of the latter; male hypopygium with the spines of the inner dististyle relatively numerous, distributed over most of the extent of the style.

Male.—Length, about 12 mm.; wing, 13 mm.; antenna, about 5.6 mm.

Frontal prolongation of head obscure yellow; nasus long and conspicuous; palpi brown. Antennae (male) of moderate length, approximately one-half the length of body; scape and pedicel obscure

yellow, flagellum brownish black; first flagellar segment long-cylindrical, with abundant and dense short pubescence, the length of the setae less than the diameter of the segment; in ***megacera***, the setae are long and coarse, the longest nearly three times the diameter of the segment. Head light brown, the front more brightened; anterior vertex relatively narrow, about two and one-half times the diameter of scape.

Pronotum testaceous yellow. Mesothorax almost uniform orange yellow, the pleura clearer yellow, the praescutum without distinct stripes; praescutal setae very small and sparse. Halteres elongate, black, the extreme base of stem yellow. Legs with coxae and trochanters yellow; remainder of legs dark brown or brownish black, the femoral bases not brightened. Wings subhyaline, a trifle more tinted than in either ***microcera*** or ***megacera***; stigma pale brown; veins brown. Venation: *Rs* relatively short and straight; ***r-m*** at or just before its fork; cell ***2nd A*** wider than in ***microcera***.

Abdominal tergites chiefly brownish black, the basal rings obscure yellow, including about the basal third or slightly more; sternites more uniformly yellow, the posterior borders of the segments very weakly darkened; seventh and eighth segments more uniformly darkened, forming a subterminal dark ring; hypopygium yellow, the dististyles with darkened vestiture. Male hypopygium with the tergite large, the caudal margin convexly rounded to almost truncate across caudal border. Inner dististyle large and compressed, with abundant dark setae and about 18 short blackened spines that are well-distributed over most of the length of the style, not arranged in a small compact group of relatively few spines as in ***megacera***; no flange on outer margin at base as in ***microcera***.

Holotype, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre).

The nearest allies of the present fly are *Tanypremna* (*Tanypremnella*) ***megacera*** Alexander and *T.* (*T.*) ***microcera*** Alexander, all three species having the thoracic pleura unvariegated and with no white color on legs. The antennae of the present fly are conspicuously shorter than in ***megacera***, with the vestiture abundant but very short. All three species show marked differences in the structure of the male hypopygia, especially of the inner dististyle.

Tipula Linnaeus

Tipula osculata sp. n.

Belongs to the ***glaphyroptera*** group; allied to ***obirata***; mesonotal praescutum with three entire dark brown stripes, the interspaces yellow pollinose; antennae (male) short, the basal flagellar segments bicolored; femora brownish yellow, with a narrow, darker brown subterminal ring; wings yellow, heavily patterned with brown; prearcular field and a broad band before cord of the yellow ground; R_{1+2} entire; male hypopygium with the posterior border of tergite produced into a short depressed lobe, the apex of which is evenly emarginate; gonapophyses at apex dilated into broad pale blades.

Male.—Length, about 13 mm.; wing, 14.5 mm.; antenna, about 2.5 mm.

Frontal prolongation of head above light brown, the sides darker brown; nasus slender; palpi dark brown. Antennae relatively short; basal three segments yellow; succeeding segments weakly bicolored, the scarcely indicated basal swelling dark brown, the distal half or more of segment yellow; outer segments uniformly dark brown; longest verticils considerably exceeding the segments in length. Head with central portion yellowish, the posterior vertex behind the eyes slightly darker; vertical tubercle low.

Pronotum obscure yellow, weakly darkened on sides. Mesonotal praescutum with interspaces yellow pollinose, the three stripes entire, dark brown, the lateral pair merging gradually with the brown lateral praescutal border; scutum dark brown, the central area obscure yellow, weakly more darkened behind the suture, scutellum obscure brownish yellow; mediotergite dark brown on central portion, more reddish brown on sides. Pleura and pleurotergite yellow, the meron a trifle darker. Halteres yellow. Legs with coxae and trochanters yellow; femora obscure brownish yellow, each with a very narrow, darker brown, subterminal ring; tibiae and basitarsi light brown, the outer tarsal segments blackened; legs very long and slender. Wings with the ground color yellow, heavily patterned with brown; the main ground areas include the entire prearcular field and a broad complete band before the cord; cell *C* a trifle more brownish yellow than is cell *Sc*; the chief dark areas include four subcostal spots, the first three extensive and produced behind into cell *R*; last area, in extreme end of cell *Sc*, small; a very large dark marking centers about cell *1st* M_2, crossing the entire wing and only slightly variegated with paler spots; outer ends of cells R_5 to M_4, inclusive, with yellow areas, the one in cell R_5 very extensive, including the distal half of cell; basad of cord, cells *Cu*, *1st A* and *2nd A* with very extensive zigzag brown areas, these being posterior extensions of the three more basal subcostal darkened areas; veins yellow, dark in the patterned portions. Venation: R_{1+2} entire, the tip pale; petiole of cell M_1 shorter than *m*.

Abdomen obscure brownish yellow, the basal tergites very weakly darkened medially, the outer tergites more uniformly darkened; hypopygium yellow. Male hypopygium with the tergite transverse, its caudal margin convex, the median portion produced into a short glabrous depressed lobe, the caudal border of which is evenly emarginate; dorsal surface of tergite with a median furrow. Basistyle small but complete, without lobes. Outer dististyle a slender cylindrical pale lobe. Inner dististyle relatively narrow, its outer lobe slender, the inner margin and apex of the inner lobe blackened. Gonapophysis at apex dilated into a broad pale blade.

Holotype, ♂, Abitagua, altitude 1,100 meters, June 8, 1941 (Macintyre).

Tipula osculata is most similar to species such as *T. consonata* Alexander, *T. juventa* Alexander, and *T. obirata* Alexander, especially to the last. The combination of entire vein R_{1+2}, subterminal dark femoral

rings, nature of the wing pattern, and the structure of the male hypopygium readily serves to separate the present fly from these similar forms.

Tipula hedymopa sp. n.

Belongs to the *glaphyroptera* group; allied to *jubilans*; mesonotal praescutum obscure brownish yellow, with a restricted dark brown pattern; femora yellow, with a narrow, nearly terminal, dark brown ring; wings bright yellow, handsomely but restrictedly patterned with brown, including washings and marblings in all cells beyond cord and in outer ends of Anal cells; cell *M* with the apical darkening along vein *Cu* conspicuous, the subapical spot correspondingly reduced.

Female.—Length, about 12 mm.; wing, 12.5 mm.

Frontal prolongation of head yellow; nasus stout, concolorous; palpi yellow, the terminal segment blackened. Antennae short; basal three segments light yellow; succeeding segments weakly bicolored, the scarcely developed basal enlargements very pale brown, the remainder yellow; verticils much longer than the segments. Head obscure brownish yellow; vertical tubercle very low to scarcely indicated.

Pronotum obscure testaceous yellow. Mesonotal praescutum obscure brownish yellow, sparsely golden-yellow pollinose, especially marked on the interspaces, the usual stripes scarcely differentiated except as follows: A triangular area on extreme cephalic portion and a restricted darkened cloud on border opposite the pseudosutural foveae; scutum yellow pollinose, each lobe with two brown areas, the one nearer the midline larger; scutellum yellow pollinose; postnotum testaceous yellow, the posterior border of the mediotergite restrictedly darkened. Pleura yellow, the anterior portion of the mesepisternum vaguely darker to produce a weak transverse girdle. Halteres yellow, the base of knob a trifle darker. Legs with the coxae and trochanters obscure yellow; femora obscure yellow with a narrow, nearly terminal, dark brown ring that is subequal in extent to the more reddish brown apex; tibiae brownish yellow basally, passing into brownish black; tarsi black. Wings with the ground color unusually bright yellow, especially the basal and costal portions; a rather restricted but conspicuous brown pattern, with slightly darker areas at *h* and arculus, origin of *Rs*, stigma and *m*; the very slightly paler brown areas include a small spot in cell *Sc*, mid-distant between arculus and origin of *Rs*, and washes and marblings in all cells beyond cord; outer end of cell *1st* M_2 and outer ends of both Anal cells slightly darkened; the subapical darkening in cell *M* adjoining vein *Cu* is reduced in size, as in *absona*, differing conspicuously from the major dark cloud found in *jubilans*; veins yellow, conspicuously darkened in the clouded areas. Venation: Tip of R_{1+2} atrophied, including less than the distal third of the vein.

Abdominal tergites orange-yellow, the basal tergite clearer yellow; lateral borders of tergites with narrow interrupted black dashes, longest and most extensive on the second segment; sternites obscure yellow; cerci relatively slender.

Holotype, ♀, Abitagua, altitude 1,100 meters, June 4, 1941 (Macintyre).

The nearest relative among the described species is *Tipula jubilans* Alexander, which differs most conspicuously in the wing pattern. In *jubilans*, vein R_{1+2} is entire whereas in the present fly the tip is atrophied but this character may not prove to be constant.

Tipula emerita sp. n.

Belongs to the *monilifera* group; general coloration buffy yellow, the praescutum with three darker stripes, the median one paler and more or less distinctly split by a capillary dark line; antennae (male) elongate, nodulose, the basal swellings oval, not abruptly subglobular as in the typical members of the group; femora dark brown with a subterminal yellow ring; wings cream-yellow, heavily patterned with light and dark brown, including a series of four subcostal brown areas; R_{1+2} atrophied; basal abdominal segments yellow, the succeeding ones dark brown; eighth sternite unarmed.

Male.—Length, about 9–9.5 mm.; wing, 11–13 mm.; antenna, about 9–10 mm.

Frontal prolongation of head obscure yellow above, conspicuously dark brown on sides; nasus distinct, yellow; palpi black, the incisures restrictedly pale. Antennae (male) elongate, as shown by the measurements; basal three segments yellow; succeeding segments bicolored, the basal enlargements black, the pedicels brownish yellow, on the outer segments passing through brown to dark brown; basal swellings of segments oval, not abruptly globular or subglobular as in the typical members of the group; verticils long, approximately two-thirds the length of the segments; all flagellar segments densely clothed with shorter erect setae. Head buffy; vertical tubercle not or scarcely developed.

Pronotum buffy. Mesonotal praescutum with the ground color buffy yellow, with three brown stripes, the median one much paler on cephalic portion and, in cases, for the entire length, more or less distinctly split by a still darker median vitta; posterior sclerites of notum obscure buffy yellow, the centers of the scutal lobes, parascutella and a strong central line on mediotergite dark brown. Pleura obscure yellow, with a more or less distinct brown girdle occupying the cephalic portion of the mesepisternum. Halteres with stem obscure brownish yellow, the knob dark brown. Legs with the coxae and trochanters obscure yellow; femora obscure yellow basally, passing into dark brown, with a subterminal yellow ring that is slightly less extensive than the darkened tip; tibiae and tarsi dark brown to brownish black. Wings with the ground color cream yellow, conspicuously variegated by light and darker brown, the latter areas including four subcostal markings that are prolonged backwards across cells *R* and *M* to vein *Cu*, the second and third confluent behind; cells beyond cord and outer ends of Anal cells very extensively clouded with somewhat paler brown; veins dark brown. Venation: R_{1+2} entirely atrophied; petiole of cell M_1 a little longer than *m*.

Abdomen with basal two tergites obscure yellow, the first darkened on discal portion; succeeding segments, including hypopygium,

dark brown. Male hypopygium with the caudal margin of tergite with two shallow notches, one on either side of the slightly produced median portion which is extended into two short points separated by a shallow groove or notch; margins of the two major notches conspicuously fringed with setae. Caudal portion of basistyle, immediately below the dististyles, with an oval lobe that is densely covered with coarse setigerous tubercles. Outer dististyle slender. Inner dististyle parallel-sided on basal portion. Gonapophyses notched at tips, the outer spine largest. Eighth sternite unarmed.

Holotype, ♂, Abitagua, Mayorga's Playa, altitude 1,000–1,100 meters, April 12, 1940 (Macintyre). *Paratopotypes*, 6 ♂♂, April 12, 1940, June 6, 1941; *paratypes*, 2 ♂♂, Cunibunda, altitude 1,100 meters, April 7, 1940 (Macintyre).

Tipula emerita is very different from the normal *monilifera* type in the oval, more gradual, basal enlargements of the flagellar segments in the male. In this respect it is approached by the otherwise entirely distinct *T. procericornis* Edwards, from very high altitudes in Ecuador (3,800 meters and over). It is becoming evident that the so-called *monilifera* and *glaphyroptera* groups of the genus, as well as the subgenus *Microtipula* Alexander, all represented by abundant species in the Neotropics, are becoming closely interconnected by the discovery of numerous new forms. It seems probable that all eventually will be placed in the last-named subgenus, with the various groups being maintained chiefly for convenience in handling the great mass of species.

Tipula luteilimbata sp. n.

Size small (wing, 12 mm.); general coloration of thoracic notum pale brown, without pattern; antennae (male) very long, approximately three-fourths the length of wing, flagellum black; wings with a strong brownish tinge, sparsely patterned with darker brown, including a large cloud near outer end of cell *M*; cord, especially *m-cu*, bordered by yellow; male hypopygium with the tergite notched medially, the low lateral lobes set with many straight black pegs; outer dististyle a small dusky lobe bearing a blackened tooth on mesal face near base.

Male.—Length, about 10 mm.; wing, 12 mm.; antenna, about 9 mm.

Female.—Length, about 11 mm.; wing, 12 mm.; antenna, about 2.5 mm.

Frontal prolongation of head relatively short and stout, obscure brownish yellow above, darker beneath; nasus short and stout; palpi black. Antennae of male very long, of female moderately so; scape and pedicel yellow, flagellum black in male, dark brown in female; flagellar segments of male very elongate-cylindrical, with scarcely developed basal tubercles; verticils much shorter than the segments; besides the verticils, the entire segment bears abundant erect pale setae that are from two to three times as long as the diameter of the segments; a third type of delicate pubescence covers the entire surface of each segment. In the female, the three types of vestiture likewise occur but in slighter degree. Head with the front and anterior vertex light yellow, the posterior vertex dark brown, more intense adjoining the eyes; anterior vertex wide, the tubercle lacking.

Pronotum yellow. Mesonotum uniformly pale brown, without pattern; vestiture of praescutal interspaces exceedingly short and sparse. Pleura uniformly yellow. Halteres relatively long, dark brown, the extreme base of stem pale. Legs with coxae and trochanters yellow; remainder of legs obscure yellow, the outer segments passing into brownish black; claws short and strongly curved, simple in both sexes. Wings with a strong brownish tinge, the prearcular field, cells *C* and *Sc*, and the stigma darker brown, especially the last; a conspicuous brown cloud near outer end of cell *M*; restricted yellow areas, including a broad seam on either side of *m-cu*, with further similar but less conspciuous areas along anterior cord, before and beyond stigma, and just basad of the darkened area in cell *M*; veins brown. Abundant macrotrichia on veins beyond cord, more sparse on M_4; squama glabrous. Venation: Tip of R_{1+2} more or less atrophied, in the male with only a basal spur, in the female with about the basal half of the vein preserved; M_{3+4} short to very short, subequal to *r-m*; cell *2nd A* relatively wide.

Abdominal tergites chiefly dark brown, the sternites and hypopygium yellow. Ovipositor with cerci long and slender, nearly straight. Male hypopygium small and of simple construction. Ninth tergite transverse, the caudal margin with a broad V-shaped notch, the low lateral lobes with many straight black spinuous pegs. Outer dististyle a small dusky lobe, the mesal face near base with a short blackened tooth. Inner dististyle subequal in length to last but stouter, with two conspicuous black teeth on margin, beyond which point the style is produced into a flattened yellow blade. Gonapophyses appearing as simple flattened blades, the tips a little wider, obtuse.

Holotype, ♂, in poor condition, Abitagua, altitude 1,100 meters, April 12, 1940 (Macintyre). *Allotopotype*, ♀, altitude 1,800 meters, April 15, 1940.

Tipula luteilimbata is readily told from all of the numerous species of the genus by the peculiar wing pattern which is entirely different from that of other described forms. The structure of the antennae and the male hypopygium provide other distinctive features. Despite the structure of the ovipositor I am inclined to believe that the species should be referred to the subgenus *Nephrotomodes* Alexander, various members of which it most nearly resembles superficially.

Tipula (Nephrotomodes) cerogama sp. n.

Size large (wing, male, 14 mm. or more); antennae elongate; mesonotum brownish yellow without distinct markings; wings with a strong brown tinge, restrictedly patterned with still darker brown; conspicuous whitish subhyaline areas before stigma and across base of cell 1*st* M_2; vein R_{1+2} preserved; male hypopygium large and bulbous, the outer dististyle very large, earlike, the inner dististyle exceedingly small, in area less than one-tenth that of the outer style; no lobes in notch of ninth sternite.

Male.—Length, about 13–14 mm.; wing, 14–15 mm.; antenna, about 7–7.2 mm.

Female.—Length, about 15 mm.; wing, 17 mm.

Frontal prolongation of head obscure brownish yellow; nasus distinct; palpi pale brown. Antennae (male) moderately long; basal three segments obscure yellow, the remainder black; flagellar segments rather strongly incised; longest verticils about two-thirds the segments. Head fulvous brown; vertical tubercle not developed.

Pronotum and mesonotum almost uniform brownish yellow, without clearly defined markings; praescutal setae extremely small and sparse. Pleura clearer yellow. Halteres with stem and base of knob infuscated, apex of knob obscure yellow. Legs with the coxae and trochanters yellow; femora obscure brownish yellow; tibiae a little darker; tarsi brownish black; claws (male) toothed. Wings with a strong brown tinge, especially in the female, restrictedly patterned with darker brown and whitish subhyaline; the dark areas include the prearcular field behind cell *C*, all of cell *Sc*, stigma and conspicuous clouds along cord, most evident on *m-cu* and the distal section of Cu_1; the whitened areas include two very evident obliterative areas, one before stigma, the second across the base of cell *1st* M_2 extending into the base of cell M_3; veins brown. Venation: R_{1+2} entire; *Rs* arcuated, longer than *m-cu*, the latter close to the fork of the short M_{3+4} or just beyond this point on M_4; cell *2nd A* relatively wide.

Abdominal tergites chiefly dark brown, especially medially, the outer segments slightly more brightened sublaterally; basal sternites yellow; a conspicuous black subterminal ring in male, involving segments seven and eight, together with the posterior portion of tergite six; hypopygium large and bulbous, uptilted, obscure yellow. Ovipositor with the valves very short and fleshy, setiferous, as in the subgenus. Male hypopygium with the tergite narrowed outwardly, the outer lateral angles produced into moderate sized lobes, the intervening caudal border truncate, provided with numerous black setae. Outer dististyle very large and complex, appearing as a compressed earlike blade, the apex obtuse; mesal face and a small curved lobe near base provided with abundant conspicuous black setae. Inner dististyle very small, in area less than one-tenth that of the outer style, appearing as a compressed blade, the narrow rostral portion blackened. Notch of ninth sternite only feebly emarginate, without lobes as is common in the subgenus. Eighth sternite relatively small, without lobes or appendages.

Holotype, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre). *Allotopotype*, ♀, in copula with holotype. *Paratopotype*, 1 ♂.

Tipula (*Nephrotomodes*) *cerogama* is entirely different from the other regional species of the subgenus. In its general appearance it is somewhat similar to *T.* (*N.*) *palaeogama* sp. n., but differs in all details of wing pattern and structure of the male hypopygium.

Tipula (Nephrotomodes) palaeogama sp. n.

Size large (wing, male, 15 mm.); general coloration of mesonotum reddish brown, scarcely patterned; wings subhyaline to weakly darkened, heavily and conspicuously patterned with dark brown, including cells *C* and *Sc*, stigma, outer radial field and a broad seam on *m-cu*; male

hypopygium with the tergite elongate, strongly narrowed outwardly, the decurved apex produced into a blackened lobe set with strong black setae and spinous points; inner dististyle on outer margin bearing a strongly flattened black blade; appendage of ninth sternite paired, strongly compressed, densely setiferous.

Male.—Length, about 13 mm.; wing, 15 mm.; antenna, about 8 mm.

Female.—Length, about 18 mm.; wing, 18 mm.

Frontal prolongation of head obscure brownish yellow above, darker brown on sides and beneath; nasus elongate; palpi dark brown, the elongate terminal segment conspicuously whitened. Antennae (male) elongate, exceeding one-half the length of wing; scape, pedicel and base of first flagellar segment obscure yellow, the remaining segments black; flagellar segments moderately incised; longest verticils a little exceeding one-half the length of the segments. Head reddish brown, without distinct vertical tubercle.

Pronotum and mesonotum almost uniform reddish brown, the praescutum without clearly differentiated stripes; setae of praescutal interspaces relatively short; setae of scutellum and postnotum longer and more conspicuous. Pleura, pleurotergite and dorsopleural membrane uniformly pale yellow. Halteres infuscated, the apices of knobs a little brightened. Legs with coxae and trochanters pale yellow; femora dark brown, obscure yellow basally; tibiae and tarsi brownish black; legs long and slender; claws (male) toothed. Wings with the ground color subhyaline and weakly darkened, as described; heavily and conspicuously patterned with dark brown, including all of cells *C* and *Sc*; stigma; outer radial field as far caudad as vein R_{4+5}, deepest in the basal portions; a very broad seam on *m-cu*; outer end of cell *1st* M_2 and fork of M_{1+2}; a restricted cloud at origin of *Rs*; prearcular field paler brown; the clearer ground areas include a major area before stigma and anterior cord, cell *M* and the basal portions of cells *Cu*, *1st A* and *2nd A*; veins brown. Venation: R_{1+2} entire; cell *1st* M_2 narrow; cell *2nd A* relatively wide. In the type, a tiny cell is cut off in the axil of cell R_2 by an adventitious crossvein just beyond vein R_2; in female, venation normal.

Abdomen dark brown, the incisures of the segments narrowly obscure testaceous yellow; in male the subterminal segments uniformly dark brown; hypopygium yellow. Ovipositor with the cerci compressed and hairy, as common in the subgenus. Male hypopygium with the ninth tergite elongate, strongly narrowed and decurved at apex, on the outer deflected portion with a blackened structure densely set with strong black setae and spinous points. Outer dististyle flattened-compressed, parallel-sided, the tip obtuse, the outer end blackened. Inner dististyle with the beak slender, the posterior lobe with abundant dense setae and more scattered stronger bristles; outer margin of style bearing a black flattened blade. Appendage of ninth sternite paired, strongly flattened and compressed, densely set with long yellow setae. Eighth sternite with caudal margin rounded, on either side of median line with numerous elongate setae forming two distinct groups, the mid-region without major setae.

Holotype, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre). *Allotopotype*, ♀, pinned with type.

Tipula (*Nephrotomodes*) *palaeogama* is entirely distinct from the now numerous species of the subgenus, differing especially in the wing pattern and in the structure of the male hypopygium. It rivals in size the largest known members of the subgenus, as *T.* (*N.*) *aymara* Alexander, of Bolivia.

Limonia Meigen

Limonia (**Limonia**) **aurigena** sp. n.

Belongs to the *praeclara* group; general coloration brown, the mesonotum with a conspicuous, golden-yellow, dorsomedian stripe; antennal scape yellow, the remainder black; legs black, with two snowy white rings, one at tip of tibia, the second on tarsi, involving only the extreme tip of basitarsi, with the succeeding three segments; wings yellowish brown, restrictedly patterned with darker brown; male hypopygium with mesal-apical lobe of gonapophysis darkened, slightly curved at tip; apex of aedeagus small, only slightly expanded.

Male.—Length, about 6.8–7 mm.; wing, 7.2–7.5 mm.

Rostrum very reduced, yellow, tipped with black; palpi reduced, black. Antennae with scape pale yellow; pedicel and flagellum black; flagellar segments oval, the outer segments more elongate; all segments except the last with very short glabrous apical pedicels; terminal segment elongate, nearly twice the penultimate; longest verticils unilaterally distributed, exceeding twice the segments. Head with front and anterior vertex pale, silvery pruinose; posterior vertex brown; anterior vertex wide, approximately four times the diameter of scape.

Pronotum pale brown, slightly darker laterally. Mesonotum medium brown with a broad, golden-yellow, median stripe extending from the cephalic border of praescutum to the abdomen, gradually narrowed behind, ending as a point on the posterior border of mediotergite; on praescutum, the stripe more intense, more or less divided by a capillary dark line, the stripe bordered laterally by a more intense darkening of the ground color, this deepened pattern bordering the pale stripe continued more or less distinctly for the entire length of the mesonotum, the lateral borders distinctly paler. Pleura obscure brownish yellow, clearer yellow on most of sternopleurite. Halteres blackened. Legs with coxae and trochanters yellow; femora black, the extreme bases obscure yellow; tibiae black, the tips narrowly snow-white, the amount subequal on all legs and involving the distal seventh or eighth; basitarsi black, the extreme tips whitened; remainder of tarsi white, only the terminal segment again abruptly black. Wings with a rich yellowish brown suffusion, the costal border weakly darkened; a restricted darker brown pattern, including small spots at origin of *Rs*, fork of *Sc*, a very small stigmal area, cord and outer end of cell *1st* M_2; veins brown. Venation: Sc_1 ending nearly opposite two-thirds the length of *Rs*, Sc_2 at its tip; *Rs* angulated at origin; inner ends of cells R_3 and *1st* M_2 about in transverse alignment and lying some distance basad of cell R_5; *m-cu* close to fork of *M*.

Abdominal tergites brownish black, even more intense laterally; sternites light yellow; incisures of outer segments restrictedly pale; male hypopygium dark. Male hypopygium characteristic of the group; basistyle with ventromesal lobe low and stout, with numerous setae. Dorsal dististyle a strongly curved blade, slightly more widened on outer third. Ventral dististyle small, its rostral prolongation long and unusually glabrous, with a small oval sensory area close to tip. Gonapophysis with mesal-apical lobe darkened, slightly curved at tip. Apex of aedeagus relatively small, not modified into a large compressed blade or flange as is the case in several allied forms.

Holotype, ♂, Abitagua, Cunibunda, altitude 1,100 meters, April 2, 1940 (Macintyre). *Paratopotypes*, 2 ♂♂, with the type.

There are several allied species in the Neotropical fauna having snowy white to pale rings on the legs, such species including *Limonia* (*Limonia*) *capnora* Alexander, *L.* (*L.*) *curraniana* Alexander, *L.* (*L.*) *limbinervis* Alexander, *L.* (*L.*) *lutzi* Alexander, *L.* (*L.*) *metae* Alexander, *L.* (*L.*) *praeclara* Alexander and *L.* (*L.*) *trialbocincta* Alexander. The present fly is closest to *metae*, differing from this and other allies especially in the leg-pattern and in slight details of the male hypopygium, notably the gonapophyses and aedeagus. The structure of the ventral dististyle and its rostral prolongation is very characteristic of the entire group. It seems further evident that still other Neotropical species having unpatterned legs, including *L.* (*L.*) *fumosa* Alexander, *L.* (*L.*) *insularis* Williston, *L.* (*L.*) *grossa* Alexander, *L.* (*L.*) *infucata* Alexander, *L.* (*L.*) *mesotricha* Alexander, *L.* (*L.*) *multisignata* Alexander, and *L.* (*L.*) *pernobilis* Alexander, belong to this same group.

Limonia (Geranomyia) stenophallus sp. n.

General coloration of mesonotum reddish, the praescutum with three diffuse, more reddish brown stripes, the lateral praescutal borders weakly darkened; knobs of halteres dark brown; wings pale yellow, restrictedly patterned with brown; *Sc* relatively long; *Rs* angulated and spurred at origin; dark areas at origin of *Rs* and fork of *Sc* separate; male hypopygium with the rostral prolongation short, truncated at apex, the two long rostral spines arising from low separate tubercles; gonapophyses with mesal-apical lobes produced into blackened spines; aedeagus unusually long and slender, narrowest at near midlength.

Male.—Length, excluding rostrum, about 6 mm.; wing, 7 mm.; rostrum, about 3 mm.

Rostrum relatively long, about one-half the length of body, black, the tips of labial palpi a very little paler. Antennae black throughout; flagellar segments oval to long-oval; verticils of moderate length. Head black; a narrow silvery line extending from the front over the vertex to the occiput, its width equal to the diameter of the anterior vertex.

Pronotum obscure yellow. Mesonotal praescutum with the ground color reddish gray, with three diffuse, more reddish brown stripes that are only poorly indicated and defined, subequal in width to the posterior interspaces; lateral praescutal borders weakly

darkened; scutum reddish brown; scutellum and postnotum obscure yellow; vestiture of notum much reduced. Pleura testaceous yellow, the dorsopleural membrane and dorsal sclerites a trifle darker. Halteres with stem pale, knob dark brown. Legs with coxae and trochanters yellow; remainder of legs broken. Wings with the ground color pale yellow, rather sparsely patterned with brown, including the oval stigma and seams at the supernumerary crossvein in cell *Sc*; origin of *Rs*; fork of *Sc*, the latter much smaller than the former and entirely separate from it; conspicuous seams along cord and outer end of cell *1st* M_2; veins pale, darker in the patterned areas. Costal fringe short and dense. Venation: *Sc* of moderate length, Sc_1 ending opposite midlength of *Rs*, Sc_2 near its tip; *Rs* angulated and short-spurred at origin; basal section of R_{4+5} long, shortening *r-m*; cell *1st* M_2 a little shorter than the distal section of M_{1+2}; *m-cu* a short distance beyond the fork of *M*; vein *2nd A* sinuous.

Abdomen with tergites pale brown or yellowish brown, provided with long conspicuous setae; sternites somewhat paler; hypopygium brownish yellow. Male hypopygium with the tergite relatively long, its caudal border only gently emarginate, the low lateral lobes provided with several long black setae. Basistyle with the ventromesal lobe relatively long but simple. Dorsal dististyle a gently curved rod, its tip abruptly narrowed into a spine. Ventral dististyle fleshy, its area about twice that of the basistyle; rostral prolongation short and stout, the apex truncate; two long rostral spines from very long separate tubercles, placed side by side on basal half of prolongation; spines long and slender, about twice as long as the prolongation. Gonapophyses with mesal-apical lobe produced into a slender acute blackened spine. Aedeagus unusually long and slender, narrowest near midlength, the distal half dilated to about twice its width at the narrowest point, the apex weakly bilobed.

Holotype, ♂, Abitagua, Mayorga's Playa, altitude 1,100 meters, April 12, 1940 (Macintyre).

Despite its very different general appearance, especially the wing pattern, I believe the nearest relative of the present fly is *Limonia* (*Geranomyia*) *hirsutinota* Alexander, which has the general structure of the male hypopygium much as in the present fly though differing in details.

Limonia (Geranomyia) refuga sp. n.

General coloration of mesonotum orange, including the disk of praescutum and the scutal lobes; scutellum testaceous; knobs of halteres dark brown; wings yellow, very sparsely patterned with brown, including the oval stigma and restricted seams at origin of *Rs* and over the supernumerary crossvein in cell *Sc*; vein *Sc* short, Sc_1 ending just beyond the origin of *Rs*; cell *1st* M_2 subequal in length to vein M_{1+2} beyond it; male hypopygium with the rostral spines arising from separate tubercles, these spines slightly unequal in diameter and length; gonapophyses with a conspicuous flange on the concave face of the mesal-apical lobe.

Male.—Length, excluding rostrum, about 6 mm.; wing, 7 mm.; rostrum, about 2.2 mm.

Rostrum black throughout, of moderate length. Antennae black; flagellar segments cylindrical to subcylindrical. Head dark brownish gray; anterior vertex reduced to a capillary line.

Pronotum obscure yellow. Mesonotal praescutum with the entire disk occupied by three confluent orange stripes, the humeral region restrictedly more yellow; scutal lobes similarly orange, the median region and the scutellum more testaceous; postnotum testaceous yellow; praescutum and scutum with sparse but very long and conspicuous erect setae, most evident near suture. Pleura yellow. Halteres with stem yellow, knob dark brown. Legs with coxae and trochanters yellow; remainder of legs broken. Wings with the ground color yellow, very sparsely patterned with brown, including the oval stigma, a small seam at the supernumerary crossvein in cell *Sc* and a restricted common seam at origin of *Rs* and fork of *Sc*; no distinct darkening along cord or outer end of cell *1st* M_2. Costal fringe short and dense. Venation: *Sc* short, Sc_1 ending immediately beyond the origin of *Rs*, Sc_2 at its tip; cell *1st* M_2 elongate, subequal to vein M_{1+2} beyond it; *m-cu* more than one-third its length beyond the fork of *M*.

Abdominal tergites obscure brownish yellow; sternites clearer yellow. Male hypopygium with the caudal margin of tergite broadly and shallowly emarginate, the low lobes with long coarse setae. Basistyle with the ventromesal lobes large, simple. Dorsal dististyle appearing as a gently curved sickle, the tip acute. Ventral dististyle very large, fleshy, in area nearly four times the basistyle; rostral prolongation relatively slender, with two rostral spines from separate tubercles, the outer spine a little longer and more slender, from a smaller tubercle; inner spine close to the base of the prolongation. Gonapophysis with mesal-apical lobe elongate, gently curved, pale, the concave face with a conspicuous flange.

Holotype, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (Macintyre).

Limonia (*Geranomyia*) *refuga* is very different from other regional species having a short *Sc* and restrictedly patterned wings. The immaculate praescutum separates it from several species having three narrow brown stripes on the praescutum. The nature of the hypopygium is most like that of *L.* (*G.*) *myersiana* Alexander, of the Greater Antilles, which has the wings unpatterned except for the stigma, and the details of body coloration distinct.

Limonia (Geranomyia) pastazina sp. n.

General coloration of mesonotum brownish yellow or testaceous brown, unmarked; rostrum elongate, black; halteres uniformly blackened; wings subhyaline, the cells beyond cord weakly darkened; stigma oval, dark brown, conspicuous; Sc_1 ending about opposite two-fifths the length of *Rs*; cell *2nd A* relatively narrow, vein *2nd A* gently and evenly arched throughout its length, not at all sinuous; male hypopygium with the apex of the dorsal dististyle narrowly obtuse; rostral spines of ventral dististyle arising from small individual tubercles; mesal-apical lobe of gonapophysis very long and slender, entirely pale.

Male.—Length, excluding rostrum, about 5 mm.; wing, 5.5 mm.; rostrum, about 2.5 mm.

Rostrum elongate, fully one-half the length of remainder of body, black. Antennae brownish black throughout; flagellar segments oval. Head dark brown, without pattern; anterior vertex reduced to a narrow strip that is narrower than the diameter of the scape.

Mesonotal praescutum, scutum and postnotum uniform brownish yellow or testaceous brown; scutellum broad, a trifle paler than the remaining sclerites of notum; notal setae very reduced to virtually lacking. Pleura testaceous yellow. Halteres uniformly blackened. Legs with coxae and trochanters testaceous yellow; remainder of legs broken. Wings subhyaline, the cells beyond cord weakly darkened; stigma oval, dark brown, conspicuous; veins brown. Venation: *Sc* of moderate length, Sc_1 ending about opposite two-fifths the length of *Rs*, Sc_2 at its tip; a supernumerary crossvein in cell *Sc*; basal section of R_{4+5} in approximate longitudinal alignment with *Rs*; cell *1st* M_2 subequal in length to or slightly shorter than vein M_{1+2} beyond it; *m-cu* at or close to fork of *M*; cell *2nd A* relatively narrow, the vein evenly and gently arched throughout its length.

Abdomen with tergites brown, the sternites brightened; hypopygium conspicuously darker, especially the ventral dististyle. Male hypopygium with the caudal margin of ninth tergite with a very broad U-shaped notch. Dorsal distisytle a strongly curved sickle, the tip narrowly obtuse. Ventral dististyle very large, exceeding three times the area of the basistyle; rostral prolongation short, truncated at apex, the spines long and conspicuous, more than twice as long as the prolongation itself, arising from small individual tubercles that are placed close together a short distance back from apex of prolongation; spines subequal in length but one more curved, both acute at tips. Gonapophyses entirely pale, the mesal-apical lobes very long and narrow, gently curved to the acute tips.

Holotype, ♂, Abitagua, Mayorga's Playa, altitude 1,100 meters, April 12, 1940 (Macintyre).

Limonia (*Geranomyia*) *pastazina* is evidently most closely related to members of the *canadensis* group, as *L.* (*G.*) *argentinensis* (Alexander), *L.* (*G.*) *austroandina* Alexander, and *L.* (*G.*) *guatemalensis* (Alexander), all of which have vein *2nd A* sinuous and not evenly arcuated throughout its length, and with conspicuously elongated basal tubercles to the rostral spines of the ventral dististyle.

Epiphragma Osten Sacken

Epiphragma (**Epiphragma**) **phaeoxantha** sp. n.

Mesonotal praescutum rich chestnut brown, the posterior sclerites darker; thoracic pleura with a broad yellow longitudinal stripe extending from the pronotum to beneath the wing root, clearly separated from a black pleural stripe immediately beneath it; legs yellow, the femora with two conspicuous dark brown rings; wings yellow, heavily marked with brown, the pattern in part ocelliform.

Male.—Length, about 8 mm.; wing, 7.5 mm.

Rostrum and palpi black. Antennae with the scape and pedicel weakly infuscated to obscure yellow; fusion-segment of flagellum yellow; succeeding segments brownish black; antennae broken beyond the tenth segment; flagellar segments long-cylindrical, with conspicuous verticils that are subequal in length to the segments; antennae relatively short. Head orange-yellow, the posterior vertex more testaceous, with a central infuscation.

Pronotum light yellow, the color continued caudad as a very broad and conspicuous longitudinal stripe to below the wing-root, becoming wider behind, involving the extreme lateral border of praescutum, the dorsopleural membrane and the dorsal portions of the thoracic pleura, the stripe behind involving the dorsal pteropleurite and pleurotergite. Mesonotum rich chestnut brown, the disk not or scarcely patterned, the lateral border conspicuously blackened; scutal lobes chestnut brown, the median area weakly darkened; scutellum and postnotum more strongly infuscated, sparsely pruinose, the lateral portions of mediotergite and adjoining portions of pleurotergite extensively obscure yellow. Pleura beneath the yellow dorsal stripe with a comparable longitudinal black stripe, its upper edge clear-cut, the ventral portion merging with the obscure yellow of the ventral sternopleurite and meron. Halteres yellow. Legs with the coxae yellow, the fore pair weakly darkened, especially on proximal portions; trochanters yellow; legs detached; femora yellow, each with two conspicuous dark brown rings, the outer one narrower than the yellow ring on either side; tibiae and tarsi yellow. Wings relatively broad; ground color yellow, the prearcular and costal fields more saturated yellow; a heavy brown pattern that is in part ocelliform, including a complete ring at origin of *Rs*; incomplete rings at arculus, along cord and fork of M_{1+2}; cell *Cu* with a single dark cloud at near midlength; outer margin of cell *1st A* with two dark dashes, cell *2nd A* with five, the innermost a larger cloud that extends into the base of cell *1st A*; dark area over the supernumerary crossvein in cell *C* not connected with other brown spots; veins yellow, a little darker in the patterned areas. Venation: R_{2+3+4} relatively short, a trifle less than two times *r-m*; *m-cu* more than three-fourths its own length beyond the fork of *M*.

Basal abdominal tergites chiefly obscure yellow, patterned with brown, the outer segments more extensively darkened; tergal impressions more yellowish; basal sternites obscure yellow, the outer segments more darkened; hypopygium obscure yellow. Male hypopygium with the interbasal rods strongly recurved at their tips.

Holotype, ♂, Abitagua, Cunibunda, altitude 1,100 meters, March 22, 1940 (Macintyre).

The broad yellow stripe on the pronotum and dorsal thoracic pleura readily separates the present fly from other regional allies. Among the now numerous Neotropical species of the genus, the closest relatives appear to be *Epiphragma* (*Epiphragma*) *amphileuca* Alexander and *E.* (*E.*) *delicatula* Osten Sacken. It is unfortunate that the apical segments of the antennae of the unique type are broken and thus it cannot be stated whether or not the outer antennal segments are abruptly whitish, as is the case in *amphileuca* and certain other species.

Ctenolimnophila Alexander

Abitagua subgen. n.

Characters as in the typical subgenus. Antennae 15-segmented; scape elongate; basal five flagellar segments united into an elongate fusion-segment, the former sutures feebly indicated, each ring thus formed with a strong bristle; sixth flagellar segment partly fused with the basal segment; succeeding seven segments more elongate, the terminal one nearly twice the penultimate; all outer segments with long verticils, including a unilaterally arranged series consisting of a single, unusually long seta on each segment, the longest bristle fully three times the segment alone. Halteres elongate. Tibiae with two strong spurs; claws simple. Wings with anterior arculus broken; vein R_{2+3+4} very long, R_2 lacking; cell M_1 lacking; cell *1st* M_2 very long and narrow, with *m-cu* at near midlength. Male hypopygium with the outer dististyle terminating in a simple truncated point; inner dististyle provided with conspicuous spines and spinous points; gonapophyses appearing as pale clubs, their tips set with numerous appressed spines.

Type of Subgenus.—Ctenolimnophila (*Abitagua*) *longifusa* sp. n. (Neotropical Region).

Ctenolimnophila (**Abitagua**) **longifusa** sp. n.

General coloration of notum light chestnut brown, without pattern; thoracic pleura with a conspicuous black longitudinal stripe; halteres elongate, yellow; legs black, the tarsi paling to obscure yellow; wings uniform pale brown, unpatterned; R_{2+3+4} and cell *1st* M_2 unusually long; male hypopygium with the inner dististyle conspicuously spinous.

Male.—Length, about 6.5 mm.; wing, 6.3 mm.; antenna, about 1 mm.

Rostrum and palpi black. Antennae with scape and pedicel black, flagellum pale brown. Head brown.

Pronotum and pretergites obscure yellow. Mesonotum almost uniformly light chestnut brown, without distinct pattern. Pleura light brownish yellow with a conspicuous black longitudinal stripe extending from the cervical region to the base of abdomen. Halteres unusually long, with small club, yellow throughout. Legs with the coxae and trochanters brownish yellow; remainder of legs black, the tarsi paling to obscure yellow. Wings with a uniform pale brown tinge, without pattern. Veins beyond cord with abundant long trichia. Venation: Sc_1 ending opposite fork of *Rs*, Sc_2 near its tip; *Rs*, R_{2+3+4} and R_3 all elongate and generally equal in length; inner end of cell *1st* M_2 lying far basad of cell R_5; *m* and basal section of M_3 in approximate transverse alignment; cell *2nd A* moderately wide.

Abdomen weakly bicolored, obscure brownish yellow, the incisures and lateral borders more strongly blackened. Male hypopygium as described under the subgenus; outer dististyle entirely sclerotized and blackened, relatively narrow and parallel-sided, the apex narrowed into a decurved point, the apex truncated; inner dististyle much stouter, the entire outer face set with conspicuous blackened

appressed spines; apex of style terminating in three or four long powerful setae. Aedeagus broadly dilated at base.

Holotype, ♂, Abitagua, altitude 1,100 meters, June 13, 1941 (Macintyre).

The present fly superficially is most like *Ctenolimnophila* (*Campbellomyia*) *neolimnophiloides* Alexander, of southeastern Brazil, and it is possible that this latter fly will be found to belong to the new subgenus as above defined. The elongate vein R_{2+3+4} and the fusion segment of the antennae suggest the conditions found in the genus *Neolimnophila* Alexander but from the structure of the male hypopygium it is certain that there is no close relationship between these two groups. The typical members of both *Ctenolimnophila* and *Campbellomyia* Alexander have the antennal segments simple and unfused and it seems probable that when more material becomes available *Abitagua* will require full generic ranking.

Atarba Osten Sacken

Atarba (**Atarba**) **procericornis** sp. n.

General coloration of thorax testaceous yellow, not or scarcely patterned; antennae (male) exceeding in length either the body or the wing; basal flagellar segments bicolored, their proximal ends yellow, the apices black; flagellar segments long-cylindrical, with conspicuous outspreading verticils; legs yellow; wings tinged with brown, the stigma slightly darker; *m-cu* about one-third its own length beyond the fork of *M*; abdominal tergites weakly bicolored, their bases yellow, the apices more broadly dark brown; male hypopygium with both dististyles unusually long, the outer at near one-third its length dilated into a triangular body, the long slender apex with seven or eight strong spines along outer border; inner dististyle unusually slender; aedeagus short and straight, unmodified.

Male.—Length, about 5 mm.; wing, 5.6 mm.; antenna, about 6.5 mm.

Rostrum testaceous yellow, with very long and conspicuous black setae; palpi dark brown. Antennae (male) exceeding the body in length, as shown by the measurements; scape and pedicel yellow; flagellar segments with the bases yellow, the tips black; on the first and second segments the two colors are about equal in extent, on the third and succeeding segments the amount of yellow progressively restricted, on segment three occupying one-third the segment, on segment five about one-fifth, on the seventh and eighth segments virtually lacking, the succeeding segments uniformly black; flagellar segments long-cylindrical, with conspicuous outspreading verticils over their total length. Head brown, very sparsely pruinose; eyes large; anterior vertex about one-half wider than the diameter of scape.

Pronotum and mesonotum almost uniform testaceous yellow, not or scarcely patterned. Pleura testaceous yellow, the dorsal sclerites a trifle darker. Halteres yellow, the knobs weakly darkened. Legs yellow, the outer tarsal segments passing into brown; tibiae spurred. Wings relatively narrow, tinged with brown, the prearcular and costal fields light yellow; stigma narrow, pale brown; veins and crossveins

very narrowly and insensibly seamed with darker; veins brown, yellow in the brightened portions. Venation: Sc_1 ending opposite origin of *Rs*, Sc_2 some distance from its tip, Sc_1 alone exceeding one-half the length of the relatively short *Rs*; *Rs* very gently arcuated, its branches long and straight; cell *1st* M_2 short, subquadrate; *m-cu* about one-third its length beyond the fork of *M*.

Abdominal tergites weakly bicolored, the bases obscure yellow, the apices more broadly dark brown, the subterminal segments more uniformly dark brown; hypopygium obscure brownish yellow, the styli darkened. Male hypopygium with the basistyle moderately long, on mesal face before apex with a small finger-like lobe; mesal face near base with a group of from eight to ten unusually strong and powerful setae. Outer dististyle long and narrow, at near one-third the length dilated into a triangular body that terminates in a strong spine; outer two-thirds of style slender, its outer border with about seven or eight strong spines before the decurved terminal one. Inner dististyle a little longer than the outer, unusually long and slender, gently curved at about one-third the length. Aedeagus straight, relatively short, moderately stout, the tip truncated and unmodified; at base of aedeagus on either side with two strong spinous points, the outermost again unequally bispinous; the exact homologies of these spines cannot be determined from the material available. No evident appendage of the ninth sternite is visible in the unique slide.

Holotype, ♂, Abitagua, Cunibunda, altitude 1,100 meters, April 2, 1940 (Macintyre).

Atarba (*Atarba*) *procericornis* is readily told from all of the now numerous Neotropical members of the genus by the very long antennae of the male and by the structure of the male hypopygium, especially the outer dististyle and the unusually slender inner dististyle The most similar of these regional forms are *A.* (*A.*) *idonea* Alexander and *A.* (*A.*) *tatei* Alexander.

Gnophomyia Osten Sacken

Gnophomyia (**Gnophomyia**) **coxitalis** sp. n.

General coloration black; antennae (male) relatively elongate, black throughout; halteres and legs black; wings with a strong blackish suffusion, vein *Cu* and the cord broadly seamed with darker; *m-cu* about opposite midlength of cell *1st* M_2; male hypopygium with the lateral angles of ninth tergite produced caudad into long lobes, the margin between these with a comb of long spinous setae; basistyle on mesal face near proximal end with a row of about five very powerful black spinous setae.

Male.—Length, about 5.3–5.5 mm.; wing, 5.2–5.6 mm.; antenna, about 2.5–2.7 mm.

Rostrum and palpi black. Antennae relatively long, nearly one-half the length of wing, black throughout; flagellar segments elongate-oval; longest verticils exceeding the segments in length. Head black, broad, the anterior vertex about three times the diameter of scape.

Pronotum black; anterior lateral pretergites very restrictedly brightened. Mesonotum black, the surface opaque or subopaque. Pleura black, the surface sparsely pruinose. Halteres black. Legs with the coxae black, sparsely pruinose; trochanters brownish black; remainder of legs black, the bases of femora, especially the fore pair, restrictedly obscure yellow. Wings with a strong blackish suffusion, more heavily seamed with brown as a broad band at and beyond cord and as a conspicuous cloud along vein *Cu* in cell *M*; stigma narrowly long-oval, still darker in color; a more or less distinct subhyaline brightening in outer ends of cells *R* and *M* before the darkened cross-band; veins black. Venation: *Sc* long, Sc_1 ending a short distance before fork of R_{2+3+4}, Sc_2 some distance from its tip, about opposite two-thirds the length of *Rs*; *Rs* straight, in alignment with R_5, the basal section of the latter eliminated or virtually so; R_{2+3+4} only slightly arcuated, in longitudinal alignment with its anterior branch; R_2 about one-half R_{2+3}; cell *1st* M_2 of moderate length, about one-half of vein M_{1+2} beyond it; *m-cu* at near midlength of cell *1st* M_2; cell *2nd A* of moderate length.

Abdomen, including hypopygium, black. Male hypopygium with the tergite transverse, its caudal margin with a dense comb of elongate black spinous setae; lateral angles of tergite greatly produced into long lobes that are provided with shorter, more appressed, spinous setae. Basistyle relatively short, the mesal face of each near base with a row of about five very powerful black spinous setae. Outer dististyle nearly straight, broadest on basal third, the apex subacute. Inner dististyle much smaller, blackened, gently arcuated, the distal end subtriangularly dilated, its apex obtuse. Phallosomic plate conspicuously bilobed.

Holotype, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (Macintyre). *Paratopotype*, ♂, with the type.

Gnophomyia (*Gnophomyia*) *coxitalis* is most nearly allied to *G.* (*G.*) *kertesziana* Alexander, *G.* (*G.*) *maestitia* Alexander, and *G.* (*G.*) *pallidapex* Alexander, differing from all in the peculiar structure of the male hypopygium, notably of the ninth tergite and the armed basistyles (coxites, parameres).

Gnophomyia (Gnophomyia) teleneura sp. n.

General coloration of mesonotum black, the praescutum virtually covered by a continuous dorsal shield; pleura yellow, the anepisternum with a conspicuous blackened spot that includes the entire sclerite or virtually so; wings yellowish subhyaline, the central cells washed with brown to about the level of the darker brown stigma; costa opposite stigma conspicuously thickened; cord of wing lying unusually basad, at about midlength of wing, the veins beyond being very long; M_{1+2} distad of the unusually narrow cell *1st* M_2 about three times the length of the cell; cell *2nd A* wide; male hypopygium with numerous very long strong setae on ninth sternite; outer dististyle slender, its tip obtuse.

Male.—Length, about 6.5 mm.; wing, 6.1 mm.; antenna, about 2 mm.

Female.—Length, about 6 mm.; wing, 6.2 mm.

Rostrum pale yellowish brown; palpi black. Antennae relatively long, as shown by the measurements; scape brown; pedicel and flagellum black; basal flagellar segments long-cylindrical, with relatively inconspicuous verticils; outer segments gradually shorter, the verticils longer and more conspicuous but still shorter than the segments; terminal segment small, about two-thirds the penultimate. Head gray.

Pronotum dark brown, pale laterally; pretergites pale yellow. Mesonotal praescutum covered by a polished black shield, the humeral region extensively yellow; region of suture, median area of scutum and the posterior border of scutellum more reddish, the remainder of mesonotum, including the pleurotergite, black. Pleura yellow, the anepisternum covered by a conspicuous circular blackened spot. Halteres with stem brown, knob blackened. Legs with the coxae and trochanters yellow; femora pale brown to yellowish brown; tibiae and tarsi obscure brownish yellow, the tips of tibiae and the outer tarsal segments restrictedly blackened. Wings yellowish subhyaline, distinctly patterned with darker; a heavy brown infuscation extending from the axillary region to beyond the cord, involving the extensive basal portions of cells *1st A*, *Cu* and *M*, as well as the bases of the outer radial cells to the general level of the stigma, the outer cells of wing somewhat less distinctly darkened; stigma oval, dark brown, conscpiuous; prearcular field and costal region light yellow; veins brown, yellow in the brightened portions. Venation: In male, cord of wing lying unusually far basad, at midlength of wing, the veins beyond cord thus of unusual length; costa opposite the stigmal area strongly incrassated and darkened; *Rs* in longitudinal alignment with R_5; R_2 relatively faint; R_{2+3+4} about three times R_{2+3}; cell *1st* M_2 very long and narrow, about one-third as long as vein M_{1+2} beyond it; *m-cu* faint, slightly less than its own length beyond the fork of *M*; distal section of Cu_1 very long, cell M_4 correspondingly very deep; vein *2nd A* strongly arched on basal third, approaching vein *1st A*, cell *2nd A* wide. In female, venation about as in male but R_{2+3+4} and veins beyond cord a trifle shorter; *m-cu* more evident, lying farther distad, at near one-third the length of cell.

Abdominal tergites dark brown, the sternites obscure brownish yellow, vaguely patterned with darker; hypopygium and preceding segment a little paler than the tergites. Male hypopygium with the sternite provided with about seven or eight very powerful setae arranged in a loose group on either side of midline, the setae directed ventrad. Outer dististyle relatively slender, its tip obtuse. Inner dististyle a compact mass consisting of a basal blackened lobe provided with a few long strong setae and an outer apical portion with apex obtuse, the margin roughened. Ovipositor with cerci relatively elongate, somewhat parallel-sided, with setae over the entire length; tips obtuse.

Holotype, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre). *Allotopotype*, ♀, with the type.

Gnophomyia (*Gnophomyia*) *teleneura* is entirely distinct from all other regional members of the genus, the most striking character being

the position of the cord at near midlength of the wing and the corresponding very unusual length of the veins beyond. The wing pattern is likewise distinctive of the species.

Gnophomyia (Gnophomyia) flebilis sp. n.

General coloration black, the meral region of the thoracic pleura more yellow; antennae and legs brownish black; halteres with stem darkened, knob light yellow; wings with a very strong and uniform brown tinge, the prearcular field restrictedly yellow; Sc_2 far from the tip of Sc_1, before the level of the fork of *Rs*; male hypopygium with the outer dististyle long and slender, gradually narrowed to the subacute tip; inner dististyle short and stout, with a strong blackened tooth at base.

Male.—Length, about 5.2–5.5 mm.; wing, 5.3–6 mm.; antenna, about 1.1–1.2 mm.

Female.—Length, about 5.5 mm.; wing, 5.5 mm.

Rostrum and palpi black. Antennae black throughout, relatively short; flagellar segments subcylindrical, the longest verticils exceeding the segments in length. Head dull brownish black.

Pronotum black, the pretergites yellow. Mesonotum black, the surface glabrous and subnitidous. Pleura black, the more ventral pleurites paler and sparsely pruinose; meral region more yellowed. Halteres with stem brown, knob conspicuously light yellow. Legs with the fore and hind coxae testaceous, middle coxae darker; trochanters obscure yellow; remainder of legs brownish black to black, the femoral bases restrictedly brightened. Wings with a very strong and uniform brown tinge, the prearcular field restrictedly yellow; veins brownish black. Venation: Sc_1 ending beyond midlength of R_{2+3+4}, Sc_2 far from its tip, shortly before the fork of *Rs*; R_2 very faint to subatrophied, placed shortly beyond the fork of R_{2+3+4}, varying from longer to shorter than vein R_{2+3} alone; *m-cu* variable, from one-third to nearly its own length beyond the fork of *M*.

Abdomen, including hypopygium and genital shield of ovipositor black. Male hypopygium with the outer dististyle unusually long and slender, gradually narrowed outwardly, the apex subacute to narrowly obtuse. Inner dististyle short and stout, obtuse at tip, only about one-third the length of outer style; at base of inner style with a strong blackened tooth or flange. Major plate of phallosome at apex narrowed into a median blackened point.

Holotype, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (Macintyre). *Allotopotype*, ♀. *Paratopotypes*, 1 ♂, 1 ♀, with types.

In its general appearance, the present fly is most similar to *Gnophomyia* (*Gnophomyia*) *lachrymosa* Alexander, differing conspicuously in the structure of the male hypopygium, especially the very long, slender outer dististyle, the basal tooth of the inner style, and the strongly narrowed apex of the phallosome. The halteres of *lachrymosa* are black throughout.

Gnophomyia (Gnophomyia) perlata sp. n.

General coloration dull black; anterior pretergites conspicuously light yellow; halteres with knob clear light yellow; legs brown, the

terminal segments blackened; wings unusually broad, especially in male, the width (male) exceeding one-third the length; male hypopygium with the outer dististyle terminating in a straight black spine; inner dististyle with the basal lobe obtuse.

Male.—Length, about 5.3–5.6 mm.; wing, 6 x 2.0 to 6.2 x 2.2 mm.

Female.—Length, about 5.5 mm.; wing, 6.2 x 1.9 mm.

Rostrum and palpi black. Antennae black, relatively short; flagellar segments suboval to elongate, the longest verticils exceeding the segments. Head black, sparsely pruinose.

Thoracic notum dull black, the surface more or less pruinose; anterior pretergites conspicuously light yellow; humeral region of praescutum and extreme posterior portions of scutal lobes slightly reddened. Pleura dull black, the dorsopleural membrane a trifle brightened; meral region yellow. Halteres with stem obscure yellow, the knob clearer yellow. Legs with the fore and middle coxae blackened, their tips more or less paler, posterior coxae uniformly yellow; trochanters brownish yellow, the posterior pair clearer yellow; remainder of legs brown, the terminal segments more blackened. Wings unusually broad, especially in male, representing the maximum in this respect as found in the Neotropical fauna; membrane strongly suffused with brown but not as dark as in *flebilis*; prearcular field restrictedly more yellow; stigma very narrow, still darker brown; veins dark brown, those in the prearcular field brighter. Venation: Sc_1 ending about opposite fork of R_{2+3+4}, Sc_2 far from its tip, about opposite the fork of *Rs*; R_{2+3+4} moderately arcuated; *Rs* in direct longitudinal alignment with R_1, as common in the genus; cell *1st* M_2 widened distally; *m-cu* variable in position, from about one-half to nearly its entire length beyond the fork of *M*.

Abdomen, including the genitalia of both sexes, brownish black. Male hypopygium with the outer dististyle a rather strongly curved blackened rod, narrowed into a long straight black spine or spike, its tip acute or subacute. Inner dististyle with the basal lobe obtuse. Phallosome with the aedeagus slender, blackened, the truncated tip pale. Ovipositor with cerci of moderate length, narrowed outwardly, the tips obtuse, with setae distributed over the entire length, as common in the genus.

Holotype, ♂, Abitagua, altitude 1,100 meters, March 18, 1940 (Macintyre). *Allotopotype*, ♀, March 21, 1940. *Paratopotype*, 1 ♂, with the allotype.

Gnophomyia (*Gnophomyia*) *perlata* has the broadest wings of any of the now numerous species known from Tropical America. In other regards it is apparently closest to *G.* (*G.*) *flebilis* sp. n., which differs further in the much more strongly darkened wings and in the details of structure of the male hypopygium, especially the dististyles.

Trentepohlia Bigot

Trentepohlia (**Mongoma**) **errans** sp. n.

Coloration of thorax uniformly pale yellow; abdomen with a narrow dark brown subterminal ring, the remaining tergites brownish yellow,

the sternites clear yellow; legs obscure yellow throughout; wings with a pale yellow tinge, the yellow veins poorly differentiated against the ground; four veins issuing from cell *1st* M_2; cell *Cu* closed by the touching of veins Cu_1 and *1st A*.

Male.—Length, about 5 mm.; wing, 5 mm.

Rostrum yellow; palpi yellow, the terminal segment a little darker. Antennae with scape and pedicel yellow, flagellum a trifle darker, brownish yellow; flagellar segments oval with inconspicuous verticils. Head pale gray; anterior vertex reduced to a narrow strip.

Thorax almost uniformly pale yellow, the mesonotum a trifle more reddish; praescutum with scattered erect setae. Halteres pale yellow. Legs obscure yellow. Wings with a pale yellow tinge, the yellow veins poorly differentiated against the ground. Venation: Sc_1 ending just beyond fork of *Rs*, Sc_2 some distance from its tip, Sc_1 alone subequal to R_2; R_2 about its own length before fork of R_{3+4}, cell R_3 thus relatively short; four branches (R_5, M_{1+2}, M_3 and M_4) issue from cell *1st* M_2, the medial branches distinct but unusually pale and subevanescent; cell *Cu* closed by the apical touching of veins *Cu* and *1st A*; cell *2nd A* relatively large.

Abdominal tergites brownish yellow, sternites clear yellow; segment eight and part of nine dark brown to form a narrow subterminal ring; hypopygium yellow.

Holotype, ♂, Abitagua, altitude 1,100 meters, June 13, 1941 (Macintyre).

Trentepohlia (*Mongoma*) *errans* is the first member of the great subgenus *Mongoma* Westwood to be discovered in the New World. In the Palaeotropical regions it is one of the largest and most characteristic groups in the Tipulidae. The present fly is certainly a member of the subgenus and its discovery in Tropical America is of unusual interest. Superficially the fly resembles certain species of the subgenus *Paramongoma* Brunetti, such as *T.* (*P.*) *pallida* (Williston).

BOOK NOTICES

A MONOGRAPHIC STUDY OF THE NORTH AMERICAN SPECIES OF THE SUBFAMILY GYPONINAE (HOMOPTERA—CICADELLIDAE) EXCLUSIVE OF XEROPHLOEA, by DWIGHT M. DELONG. Graduate Studies, Contributions in Zoology and Entomology, No. 5, Biological Series. Published by THE OHIO STATE UNIVERSITY, Columbus 10, Ohio. 1943. Pp. xiv+116, 35 plates. 6¼ x 9 inches. Price, $3.00.

For many years the homopterous family Jassidae remained one of the most neglected in the order and except for a few outstanding revisioned papers by Signoret, Spånberg, Ball, Osborn and Kirkaldy, only general faunistic works on the Homoptera as a whole, such as Melichar's Middle European and Ceylonese monographs, Distant's Fauna of British India and Fowler's Biologia Centrali-Americana, had been published prior to 1920. In the early twenties the late Professor C. F. Baker came to the conclusion that a complete revision of the group was essential before further work was possible. With the cooperation of a number of specialists and museum curators, he framed a new classification. The old Jassidae were raised to superfamily rank and split up into eighteen families, most of which were further divided into subfamilies and tribes. Naturally this

classification was purely tentative and was not meant for publication, but only as a basis on which the study of the superfamily could be developed. Professor Baker hoped that by international cooperation it would be possible eventually to place all the known genera within this framework and to modify it if necessary before publication. In 1923 he published prematurely an abbreviated form of this classification as a synopsis of families of Jassoidea (Baker, 1923, Philipp. Jour. Sci., 23(4): 351), in which he gave only fifteen families and no subfamily divisions. The families Eupelecidae, Euscelidae, Typhlocybidae and Eurymelidae were purposely omitted. Unfortunately Baker's early death brought his ambitious project to an unhappy end and the full classification has never been published. Since then, however, work on the superfamily has been greatly intensified and a very considerable amount of revisional work has been done and hundreds of new genera and species described, but we are still very far from achieving Baker's object, the proper major classification of the Jassoidea. Recently specialists such as Oman and Evans working independently have attempted some revision of the major categories. The latter, basing his classification on head structure, venation, and genitalia, has arrived at some surprising results which definitely modify Baker's tentative arrangement. But the majority of workers have been content to confine themselves to generic and specific revisions. Professor DeLong's book comes under this heading and he has done valuable work in this latest contribution to the onerous task of describing and classifying the enormous number of North American species belonging to this subfamily. The Gyponinae are particularly difficult to deal with, comprising as they do so many superficially similar species. Professor DeLong, however, was able to study a great many of the type specimens, in particular those of Spångberg's species from the Stockholm Museum, and to clear up many doubtful points.

The book is arranged in the usual manner, the introduction with acknowledgments being followed by general information on the family and on the distribution and occurrence of the species. Then comes a key to the genera dealt with in the monograph. Each genus is taken in turn, described, and a key to the species is given, followed by a short description of each included species. Altogether 13 genera and 170 species are described, of which 6 genera, 90 species and 7 varieties are new to science. There is a short bibliography followed by 35 plates comprising over 600 good line figures illustrating the characters used in the monograph.

In a work of this kind it is not possible to be other than brief in the treatment of the subject since the primary object is to get on with the description and classification of the legion of unknown forms with which we are surrounded. Nevertheless we regret that Professor DeLong has said practically nothing of the position of the Gyponinae in the major classification of the superfamily Jassoidea nor of what has happened to the genus *Zinneca* A. & S., 1843, which Van Duzee includes in the Gyponinae in his Catalogue of North American Hemiptera. He apparently follows Van Duzee (1919) in placing *Penthimia* Germar in the Gyponinae but Baker (1923) regarded the Penthimiidae and Gyponidae as distinct families. Recently Evans (Psyche, 48: 113; 1941) regards these two families as distinct subfamilies of the Bythoscopidae, and there is certainly greater difference between *Penthimia* and the other gyponine genera dealt with by DeLong than there is between the other gyponine genera themselves. The North American genus genus *Zinneca* A. & S. listed by Van Duzee is synonymous with *Idiocerus* Lewis 1836, formerly placed in the *Bythoscopidae* and erroneously transferred by Oman to the *Eurymelidae* but now the type of a new family, the *Idioceridae* of Evans.

—W. E. China, British Museum.

THE PHYLLOPHAGA OR MAY BEETLES OF GEORGIA, by P. W. Fattig. Emory Univ. Mus. Bull. No. 2; 32 pages. Published by Emory University, Emory University, Ga.

Professor Fattig is located in one of the richest faunal areas in North America, that of the Southern Appalachian Mountains. The botanist Asa Gray of Harvard pointed this area out many years ago. It has more species of plants than any similar area north of Mexico. Seventy species of Phyllophaga are listed with details of distribution, host plants when known and the present location of specimens of rarieties.—C. H. K.

INSECTS AND OTHER PESTS ATTACKING AGRICULTURAL CROPS, by E. O. Essig and W. M. Hoskins. California Agr. Extension Service, Circular 87 (Sept., 1934) revised Jan., 1944. 197 pages, 182 figs. Published by the College of Agriculture, University of California, Berkeley, Calif. Unbound.

Some California Chamber of Commerce must have had its collective backs turned when this volume came off the press. It is "inside information" for the California farmer and fruit grower. The many illustrations are excellent and its quality can be gauged by the names of the well-known entomologists who helped with the work. These are listed: H. J. Quayle, G. F. MacLeod, R. H. Smith, J. E. Eckert, S. F. Bailey, A. D. Borden, L. M. Smith, A. E. Michelbacher, G. L. Smith, E. G. Linsley, W. H. Lange, E. M. Stafford and R. L. Usinger.—C. H. K.

CATALOGUE OF THE REDUVIIDAE OF CHINA, by William E. Hoffman. Lingnan University Sci. Bull. 10, pages iv and 80. 1944. Published by Lingnan University, Canton, China. Printed by the George Banta Publishing Co., Menasha, Wis. Price $0.75.

"The final manuscript for this bulletin was prepared under difficulty, in a Japanese internment camp, and sent by 'underground' and air mail to the United States where my brother kindly undertook to see it through the press." * * * "The work of identification was carried out at the British Museum and the United States National Museum in 1940. * * * The present index to the literature should facilitate further study of the family in China and neighboring countries."

Under each species name is given a complete synonymy, each reference with locality of capture and journal of publication, then two paragraphs of "new" localities from the collection at Lingnan University, the British Museum, and a paragraph on extent of distribution.—C. H. K.

REVISION OF THE NORTH AMERICAN GENERA OF THE PHALAENID SUBFAMILY PLUSIINAE (LEPIDOPTERA), by J. McDunnough. Memoirs of the Southern California Academy of Sciences, Vol. 2, No. 2, pp. 175–232, Pl. I–V, May 1, 1944. Price $1.50.

The brief introduction to this revision states no specific purpose other than a long-needed critical study of the group, and no outline of procedure other than brief mention of a careful study of structural characters. Lepidopterists who have been familiar with the author's work on the order will take his name as a guarantee of care and thoroughness in the study; some of them, including the reviewer, may wish that the published results might have included more than a treatment of the genitalia.

Since genitalic structures may be, and in this group apparently are adequate for the separation of even closely related species, the revision will be a great help to taxonomists, the more so because of the inclusion of descriptions and figures of female genitalia as well as male. At the existing stage of our knowledge of North American Lepidoptera the reviewer continues to regard a revision as a good opportunity for more extensive treatment embracing a reasonable thorough survey of all knowledge of the included material. Ecological facts are often meager, hence this ideal is little more than a desire for the evaluation of all characters in place of the heavy emphasis on genitalia that the last thirty years have witnessed. Entomologists can hardly enjoy the same discriminating appreciation of these organs that the insects themselves must have, but are more likely to see wings and other appendages and to attempt identification by these more obvious structures and by color and pattern.

During the war we must recognize handicaps in publication. Perhaps in normal years it would be more reasonable to express a wish for figures of the insects, even though their delineation elsewhere may be entirely adequate for those who have the necessary publications.

In short, while the study does not attain the reviewer's ideal of a revisional article, it is an excellent and scholarly evaluation of the group based primarily on genitalia, and as such will be another assurance of Dr. McDunnough's high place among North American lepidopterists.—A. W. L.

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